BULLETIN OF THE

TAYLOR SOCIETY

A SOCIETY TO PROMOTE THE SCIENCE AND THE
ART OF ADMINISTRATION AND OF MANAGEMENT

SYMPOSIUM

STOP-WATCH TIME STUDY

AN INDICTMENT AND A DEFENSE

Frank B. Gilbreth and L. M. Gilbreth

Carl G. Barth	Morris L. Cooke
Dwight V. Merrick	Thomas W. Mitchell
Robert T. Kent	Reynold A. Spaeth

AUG 10 1921

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(Extract from the Constitution)

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   B. Labor
   C. The Manager
   D. The Employer

2. To secure the gradual elimination of unnecessary effort and of unduly burdensome toil in the accomplishment of the work of the world.

3. To promote the scientific study and teaching of the principles governing organized effort, and of the mechanisms of their adaptation and application under varying and changing conditions.

4. To promote general recognition of the fact that the evaluation and application of these principles and mechanisms are the mutual concern of the community, labor, the manager and the employer.

5. To inspire in labor, manager and employer a constant adherence to the highest ethical conception of their individual and collective social responsibility.

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CONTENTS

COMMENT - - - - - - - - 97
STOP-WATCH TIME STUDY: A SYMPOSIUM - - - - - 99
1. AN INDICTMENT
Frank B. and L. M. Gilbreth 100
2. A DEFENSE
Carl G. Barth - - - - - 108
Dwight V. Merrick - - 111
Robert T. Kent - - - 112
Morris L. Cooke - - - 112
Thomas W. Mitchell - - 113
Reynold A. Spaeth - - 114
3. CLOSURE
Frank B. and L. M. Gilbreth 117
REVIEWS - - - - - - - 136

COMMENT

AN editor's technique is in many respects similar to that of the teacher; both at times strive to draw facts and ideas and conclusions out of students or contributors, as a stimulus to further and independent observation, investigation, thinking, and the determination of the present state of knowledge about the thing discussed. As part of such technique both frequently assume deliberately a neutral attitude, limiting their contributions to a summing up of discussion or to casual observations which stimulate to further investigation and thought, for frequently participants believe discussions closed when they are but opened. So let it be with respect to the symposium on stop-watch time study printed in this issue.

ONE brings from a reading of the symposium the impression that, although the point at issue is apparently limited and definite, in the discussion issue is not clearly joined. The Gilbreths seem to place most of their emphasis on motion study, determination of the one best way based on a study of the best man available, the determination of ideal or ultimately attainable time standards, and the value to transference of skill and education in its broader aspects of all which the micromotion technique yields. The proponents of the stop watch, on the other hand, seem to concede what is claimed for micromotion technique with regard to the above characteristics (a simple, matter-of-fact concession, however, unaccompanied by any statement of their valuation of what is conceded), and focus their discussion on the determination of standard times and standard rates for current use. The definite point which remains at issue, therefore, seems to be whether the stop-watch technique is so "unscientific" as to be unsuitable for the determination of standard times and standard rates as a basis for current wage contracts.

WE should like to see more data concerning the point at issue. Facts are absent from this discussion; the arguments are essentially *a priori*. *Prima facie* the Gilbreths present a strong argument, in simple form somewhat as follows: *Premises;* the best man available is studied; micromotion technique gives more accurate measurement than stop-watch technique; the film gives and preserves more detail information concerning conditions; a final average can be no more accurate than the most faulty item from which it is derived; *Conclusions;* the unit time resulting from averaging micromotion observations is more accurate than that derived from averaging stop-watch observations; the net operation time computed from these is more accurate; the computed delay and other allowances are more accurate because they have a definite relation to the more accurate net operation time; therefore, the computed final standard time is more accurate. There is in this reasoning that which makes a strong appeal, but it must be admitted also that the proponents of the stop-watch technique present a strong counter *a priori* argument and the burden of proof rests with the Gilbreths—the affirmative in the debate. Therefore the membership of the Taylor Society is justified in asking for evidence,—data in the nature of actual figures of relative average unit times, relative net times, relative standard times and relative costs of securing these.

THE argument of the proponents of the stop-watch technique, which presents such strength as to justify this demand for facts, may be summed up as follows:

1. Granted that the micromotion observations are more accurate, it does not necessarily follow that the unit average of these is more accurate. It is not the whole truth that a final average can be no more accurate than the accuracy of the individual data from which they are derived. The law of compensating error may make absolutely accurate the average of a series of observations practically all of which are inaccurate, especially in the case of repeated observations of the same object. Astronomers and geodesists know that their observations with instruments of precision are inaccurate and compute what they call the "most probably correct" measurement mathematically; it is this computed "true" measurement (which may not coincide with a single observation) which permits the remarkable accuracy in their subsequent calculations. Therefore the computed micromotion net operation time is not necessarily more accurate than the computed stop-watch net operation time.

2. The film *is* superior in recording data for motion studies, and for determining in *minute detail* the one best way to teach a new generation of skilled workers without fixed psycho-manual habits, but only in exceptional operations is it superior in determining new psycho-manual methods for workers with fixed habits, and it is not necessarily at all superior in determining applicable standard times for current use by workers of fixed habits.

3. Furthermore, the micromotion final standard time, like the stop-watch final standard time, includes allowances for rest for overcoming fatigue and for other forms of unavoidable delay and avoidable delay (*Closure*, paragraph 85). Now this additional delay time to be added to arrive at a final standard time is a matter of calculation and judgment and places both methods on practically the same basis with respect to the final standard time. These allowances are considerable and at this point the value of the original micromotion accuracy in observation may disappear.

4. Finally, the micromotion technique introduces a special necessary allowance not introduced by the stop-watch technique with respect to the computation of a standard time for immediate use in a particular plant, in that a time computed on the basis of observations of the exceptional best man must be adjusted for application to men as they average in a plant (*Closure*, paragraph 111, "due allowance must be made accordingly"). At this point the value of the original micromotion accuracy in observation entirely disappears.

5. Therefore, in accordance with the statistical principle cited by the Gilbreths, that "the total can be no more accurate than its most faulty item" (King, p. 76), the accuracy of the micromotion technique *for purposes of determining standard times for current use* can be no greater than the accuracy of the allowances and adjustments no matter how accurate the original measurements may have been. The Gilbreths are not unaware of this point, for they say; "if 'time data' is all that is wanted, a stop-watch probably is close enough. It certainly is close enough for those who are interested in their work only temporarily" (*Closure*, paragraph 46).

FROM the Gilbreths, therefore, we should like to have more data,—descriptions of cases, and figures contrasting micromotion and stop-watch results in determining currently usable standard times and rates. We should like to see the proponents of the stop-watch join with the Gilbreths in making these comparative studies comprehensive and convincing. We should like to have these data for all types of operations, such as the operations of road construction or mining, lathe or boring operations on large and small parts, and machine type-setting or sewing operations. We should like to have also comparative costs, for if the micromotion results should prove to be superior in having a smaller coefficient of error, we should like to know the additional cost, if any, of securing the lesser error. From the proponents of the stop-watch technique we should like to have, not merely acknowledgement of the motion-study value of the micromotion technique, but an appraisal of its social value, in general and particularly in education for the crafts; and an argument for its adoption by research organizations, associated employers, trade associations, trade unions, trade schools and other organizations capable of bearing the cost, if it is greater, of such refined methods as a step towards future improvement of the crafts.

It is a principle of scientific management that no principle or mechanism should be considered permanent; but the burden of proof rests on the advocates of the new.

H. S. Person

SYMPOSIUM

STOP-WATCH TIME STUDY

AN INDICTMENT AND A DEFENSE

FOREWORD

AT a meeting of the New York Section of the Taylor Society, December 16, 1920, Frank B. Gilbreth presented a paper prepared by himself and Mrs. Gilbreth on "Time Study and Motion Study as Fundamental Factors in Planning and Control: An Indictment of Stop-Watch Time Study." This paper was printed for private distribution by Mr. and Mrs. Gilbreth.

Mr. and Mrs. Gilbreth's argument against the stop watch and in favor of micro-motion study seemed so significant to the members of the Taylor Society that the first opportunity was seized for a general discussion of the subject. This general discussion was held at a meeting of the Philadelphia Section of the Taylor Society, April 11, 1921.

The original paper presented by Mr. Gilbreth at the meeting of the New York Section is here reprinted as the first contribution to the symposium; the remaining contributions, including Mr. Gilbreth's concluding statement (revised and expanded), represent the discussion at the meeting of the Philadelphia Section.

For the benefit of those readers who are not familiar with the stop watch and the Gilbreth micro-motion apparatus, the following simple explanation of each is added.

The stop watch used is identical in principle with that employed in timing athletic events except that the dial is decimal, i.e., is graduated in hundredths, and the watch is calibrated so that the hand makes one revolution in exactly a minute. Therefore hundredths of a minute can be read. In addition the observer uses an "observation sheet" on which is written the sequence of elements of the operation to be observed in accordance with a preliminary analysis of the operation and data concerning the surrounding conditions. Stationing himself so that the watch and the observation sheet are held in the direct line of observation of the worker, the observer watches the worker and makes notes of the time of beginning and completion of each element of the operation. From these recorded times the lapsed time of each element is afterwards computed. A dozen or more such observations are made, the lapsed times for each element compared, and by consideration of the arithmetic average, mode and median of these a standard time for each element is determined. The sum of these standard times of the elements of the operation plus an estimated allowance for "delays" (fatigue, etc.) becomes the standard time for the operation.

The micro-motion apparatus consists of moving-picture camera, a clock of which the dial is graduated into hundredths and the hand makes a complete revolution in exactly one minute, slates with recorded data and a background (wall) ruled into squares of known dimension. A film is then made of the operation, including clock, slates and background squares. A study of this film, the negatives of which are taken at the rate of sixteen or more to the second, enables one to determine with precision the sequence, direction and duration of elements of the operation, for the camera catches and registers the time of the beginning and conclusion of an elementary motion with an exactness not possible by an observer with the stop watch. By these films the worker can be taught "the one best way" and a standard time can be computed for each elementary motion, a "delay" allowance computed, and a standard time for the complete operation determined.

We hope that a continuation of this discussion will take the form of the presentation of accumulated data. As it now stands it is a record of opinions. When opinions of experienced technicians do not agree the Taylor Society, and the public which it serves, have a right to request the submission of the data on which the several opinions are based. (Editor)

I. AN INDICTMENT OF STOP-WATCH TIME STUDY[1]

By Frank B. Gilbreth and L. M. Gilbreth[2]

Planning and control and all other functions of management depend first, last and all the time upon the standards on which they are based. These standards, in turn, depend upon the fundamental data from which they are derived. The fundamental data for determining standards are obtained by motion study and time study.

2. Dr. Taylor said: "What the writer wishes particularly to emphasize is that this whole system rests upon an accurate and scientific study of 'unit times,' which is by far the most important element in modern management."[3] We wish to give additional emphasis to his words—"accurate" and "scientific."

3. At the time that Taylor wrote this, in 1903, in his classic "Shop Management," professional paper No. 1003, Transactions of the American Society of Mechanical Engineers, the stop watch was the most accurate device and method extant. Today the stop watch is known to be vastly inferior to the method of timing and recording the motions and the attending conditions simultaneously."[4] It has been proved absolutely worthless and also misleading so far as assisting in skill study is concerned.[5] It is unethical because it does not clearly define the subject matter of an implied contract on which the wage payment is based, and it is economically wasteful because it does not preserve the best that has been done.

4. It is the validity of data accumulated by the usual use of the stop watch time study methods that we are assailing in this paper.[6]

5. Every statistician knows, and to most students of science it would seem almost axiomatic, that *final averages are no more accurate than the data from which they are derived.* It is therefore a fact that the accuracy of the standards of Planning and Control can be judged and estimated by the degree of accuracy of their fundamental data, and that effective planning and control, which involve the factors of permanence and maintenance, depend upon the validity and accuracy of the original data from which they are derived.[7]

6. Apparently in ignorance of this fact—papers and books have been written on Time Study in which are advocated the practice and method of crossing out, and discarding, times recorded by the inaccurate stop watch method, which at the time the time study data are worked up are *guessed* to be "abnormal," because they seem to be much higher or much lower than the others. In these papers and books is recommended the practice of making arithmetical calculations based upon averaging the remaining times to the fourth decimal, or *the ten-thousandth of a minute,* although the watch on which the original readings or pressings were made had no divisions smaller than a hundredth of a minute, and no observer claims that his records are always accurate to a fiftieth of a minute.[8]

7. This Society has spent much effort in standardization. It is especially to be congratulated on the choice of subject of Mr. Lichtner's paper delivered on the subject recently, which presents the necessity of deriving standards, and not only calls upon this Society to do something definite, but suggests that such fundamentals as definitions of terms become the subject of discussions and final agreement.[9]

8. It is to be regretted that up to today not one single standard has been made from the results of precise measurement by this Society, in spite of the fact that Taylor wrote, in 1903, "The adoption and maintenance of standard tools, fixtures and appliances, down to the smallest methods of doing all operations which are repeated, is a matter of importance, so that under similar conditions the same appliances and methods shall be used throughout the plant. This is an absolutely necessary preliminary to success in assigning daily tasks which are fair and which can be carried out

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[1] Full title:—"Time Study and Motion Study as Fundamental Factors in Planning and Control: An Indictment of Stop-Watch Time Study."

[2] Consulting Engineers, Montclair, N. J.

[3] A. S. M. E. edition, paragraph 133, Harper edition, page 58. This differs here from the A. S. M. E. in omitting the parentheses from *unit times* and in changing *modern* to *scientific.* See also "Shop Management," A. S. M. E., paragraph 154, Harper edition, page 65, and A. S. M. E., paragraphs 323-324, Harper edition, page 148.

[4] "Applied Motion Study," Macmillan & Co., pages 62 and 82.

[5] "Motion Study for the Handicapped," E. P. Dutton & Co., page 70.

[6] For description of other basic defects, see "Fatigue Study" and "Psychology of Management," Macmillan & Co.

[7] Willford I. King, "Elements of Statistical Method." Page 76, "The total can be no more accurate than the most faulty item." Page 77, "The absolute accuracy of a total can be no greater than that of the most inaccurate item composing it."

[8] Dwight V. Merrick, "Time Studies for Rate Setting," The Engineering Magazine Co., page 8.

[9] William O. Lichtner, "Promulgation of Standards by the Taylor Society," Rochester, N. Y., May 7, 1920.

with certainty."[10] Taylor also says, "It would seem almost unnecessary to dwell upon the desirability of standardizing, not only all of the tools, appliances and implements throughout the works and office, but also the methods to be used in the multitude of small operations which are repeated day after day.[11]

9. At the time of the presentation of Mr. Lichtner's paper, we objected to many parts of it and particularly to his definitions of various terms which involved time study and motion study, and their likenesses and differences. What Mr. Lichtner has described as motion study has no resemblance to what we had, or still have in mind, when we coined the phrase, "motion study." We have since supplemented this criticism, which aims to be most definite and constructive, by an indictment of stop watch time study made before the Society of Industrial Engineers at the recent meeting in Pittsburgh, and we shall take his paper up in detail later. Believing, however, that such an indictment should also be made in definite and detailed form before this Society, whose members are fitted by training and experience to appreciate the vital importance of the subject and to judge as to the justness of the criticism, we are today presenting this subject in summary form for your consideration. The data upon which our conclusions are based have been and are still at your disposal. A more lengthy presentation of the subject is in preparation, and that will soon be at your disposal also.

10. You undoubtedly are aware that the usual theory and practice of stop watch time study, as generally practiced, is as follows: The time that it takes "a first-class worker" or "the average worker" to do a piece of work by the usual method is obtained by using inaccurate methods and devices. The records obtained through such timing are submitted to varying processes of arithmetic in which the utilization of "averages" of incorrect data forms an important part in the calculation, with the result that the final data are not correct and neither do they define nor describe nor record the method of work which they time.

11. According to those who still advocate and use the stop watch method of time study only, the time taken to perform the work is the most important element of the final standard, this time being calculated from an "average" time for performing the work.[12]

12. We attack the validity of standards for planning and control derived according to any method based on or that uses the practice of averaging inaccurate data, and we attack the validity and the scientific value both of the method and of the results. This constitutes our definite criticism. We base this attack upon stop watch time study, for example: as described in "Time Studies for Rate Setting," by Dwight V. Merrick, copyrighted by the executor of the estate of Frederick W. Taylor, with a foreword by Carl G. Barth, and published 1919. This book, it will be noted, is by a recognized authority in stop watch time study, of recent date, introduced and indorsed by the Taylor Co-operators. It is a masterly presentation of the entire case for stop watch time study —authoritative, detailed and exhaustive, and reflects great credit upon the painstaking effort of the author.

13. In Mr. Barth's foreword, and in Mr. Merrick's preface to his book, and also in Chapter 1, "Objects and Principles of Time Study," and Chapter 2, "Taking An Operation Time Study," are set forth the underlying principles and the accepted practice of stop watch time study. In these first nineteen pages, the following defects in such study from the scientific standpoint are some of those which are noted:

14. Time studies are made of workers *not* extraordinarily expert. (Barth page IX. "It is at all times easiest and best to make observations on a first-class, but not extraordinarily expert operator.")

15. The data are inaccurate. (Merrick, page 8. "An error in reading the stop watch may easily equal the elapsed time for the performance of the particular element under observation.")

16. The quality and ability and suitability of the man observed has not definitely been recorded. (See figures 1, 3, 9, etc.)

17. Judgment instead of measurement is used when a mediocre worker is observed, or when "soldiering" is suspected. (Page 5-6. "The experienced observer, acquainted with the character of work, with effective and efficient methods of performing simple manual and mechanical operations, and who is also a keen student of human nature, soon learns to recognize with certainty any tendency on the part of the operators not to do their best and to make due allowances for the resulting inefficiencies, etc.")

18. Judgment, not measurement, determines the number of observations to be taken. (Page 12. "The requisite number of observations is a matter which has to be left to the judgment of the time study man.")

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[10] "Shop Management," A. S. M. E., paragraph 269, Harper, page 116.

[11] "Shop Management," A. S. M. E., paragraph 284, Harper, page 123.

[12] Merrick, "Time Study for Rate Setting," Chapter 1, paragraph 1.

19. Selections of the records to be used and averaged is left to judgment, not determined by measurement. (Page 12. "The striking out of abnormal values, either excessively higher or lower than the average of all the individual times of the same element, is a detail that calls for fine judgment on the part of the time study man.")

20. While the "curves" given are based on "data from a vast number of time studies" (page 15), the data are all inaccurate. No amount of intricate mathematics and carrying out of results to the —nth decimal point can make the results more accurate than the original data.

21. The preparation time is inaccurate. (Page 16. "The time allowed for performing these operations is standard, being arrived at from previous time study, and, in some cases, is more or less liberal.")

22. The time allowed for probable or possible delays is inaccurate. (Page 16. "To the preparation time an arbitrary allowance of 25 per cent is made to offset any variation, interference, etc.")

23. These are only a few typical objections that can be cited against stop watch time study. They are given here to illustrate the method of this attack. We have already prepared a review of the balance of the entire book in this manner, for future presentation. The reason for criticism will be given later in this paper.

24. Against this method of deriving standards, we place the method of accurate measurement and present a standard from which just and satisfactory allowances will be made for conditions of practice—a standard suitable for the instruction, assistance and profit of those who will actually do the work.[13] This standard is the *one best way to work.*[14] It is the best method obtainable at present, derived from accurate records that are in every case made by instruments of precision, without either the suspicion or the fact of personal error and that enlist the co-operation of the workers because they are indisputably accurate and fair.

25. Previous indictments of stop watch time study have been largely made from the psychological standpoint, psychology being understood as "the science of human behavior."[15] The early history and records of stop watch time study show that there was no recognition of the fact that the worker's craft knowledge, craft skill and co-operation were necessary if interchangeable records of permanent value were to result. Frequently records were made not only without the workers' co-operation, but even without his knowing that such records were being made.[16] This is not to discredit the early users of the stop watch method, but is indicative of the state of industry at that time and of a lack of knowledge of the close relation in both theory and practice between the laws of psychology and the problems of successful management.

26. With the gradual appreciation of the laws of psychology and the importance of their application, some few, but not all, of the causes of the psychological objections to stop-watch time study have been gradually disappearing, until today secret stop watch time study, which was once so common, has become practically a thing of the past, and such things as "hidden watches in watch books,"[17] used for secret time study and for spying upon the workers, are obsolete, not only because they were unethical and in many cases unfair to the workers, but also because any time study made without the full co-operation of the worker is not worth the money value of the time it takes to obtain it. It may be well also to call attention to the difference between "full co-operation" of the semi-passive type and the "enthusiastic, hearty co-operation" that exists when workers desire to contribute their craft knowledge and craft skill in detail to fellow workers and coming generations on the permanent photographic record.

27. These statements and others to follow must in no wise be taken as an implied criticism of Mr. Taylor, the great founder of stop watch time study, who was the first to make practical method of predetermining "the time it takes to do work," or in other words the possibility of prophesying "how much work can be done in a given time," by timing the work periods and the rest periods separately, nor of Prof. Wentworth of Phillips Academy, Exeter, from whom Mr. Taylor says that he first got the idea of using a stop watch for timing work."[18]

28. The recognition of the importance of timing in

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[13] "Applied Motion Study," Chapter IV "Motion Study and Time Study Instruments of Precision."

[14] "The One Best Way to Do Work," Society of Industrial Engineers, May, 1920.

[15] Edward Thorndike, "Educational Psychology," Volumes I, II and III. Stephen S. Colvin, "The Learning Process," "Human Behavior."

[16] "Shop Management," A. S. M. E., paragraph 332, Harper, page 152. Note that Taylor does not approve of "spying upon the workman."

[17] "Shop Management," A. S. M. E., paragraph 332, Harper, page 153.

[18] Tuck School Conference.

one group, or as one unit, many cycles of motions, which Taylor called "elementary time units," instead of timing "overall" or "elapsed time" or "production studies" for a complete operation as had been commonly done previously, was a milestone in the progress of management.[19] But it must be remembered that these "elementary time units" were elementary only so far as the limitations of the crude method of stop watch timing was concerned. Also, though Taylor realized the importance of timing the smallest units possible, the most that could be done with the stop watch method was to time units consisting of groups of several cycles of motions. These so-called "elementary time units" must not be confused with the sixteen subdivisions of a cycle of motions or with the methods of motion study used in analyzing and measuring them.[20]

29. The methods used by Mr. Taylor at an early stage in the development of management, the devices used by him early in his career, were the best existing at that stage of the art. The attitude of the management and of the public at large toward the worker was so different then from what it is today that the generation just entering industry can scarcely realize it.

30. One need go back but a few years to find a lack of knowledge of psychology in general and in particular of the laws and phenomena of behavior, of habit formation, and of the phenomena of automaticity, the learning process, especially learning through the eye and the variables of skill study as well as of the effect of the emotions and intellect upon activity to be astounded. It must be remembered, however, that the science of psychology itself has advanced enormously since Taylor's early days.

31. It is less than a decade ago that pschology of management was practically unknown, and often confused by the general public with psychiatry or phrenology or investigations into the field of psychic phenomena. Today the findings of the science of psychology have become tools for thinkers in all lines of endeavor.

32. Most stop watch time study advocates have recognized the justness of many of the psychological criticisms, and have done away with, yes proved away with, "secret" time study.[21] The stop watch method now, in most cases, includes attempts to enlist the cooperation of the worker, and is gradually coming to acknowledge the necessity of recording *behavior* when recording *time,* as well as recording surrounding conditions as variables affecting behavior, fatigue and production.

33. With the stop watch method, behavior cannot be recorded. It is the accurate recording of behavior and the surrounding and influencing conditions that has made motion study a science, and that has made possible the derivation, teaching and perpetuation of the one best way to do work. That the stop watch method can never lead to the one best way can be realized by a moment's consideration of the vast number of possible combinations and permutations of the true "elements" performed in any operation too rapidly for the eye to see. Such consideration will convince anyone that accurate records, fit to serve as a basis of permanent methods and teaching, can be obtained only by motion study. "Motion study," as here used, does not mean the kind of motion study that has been carelessly and erroneously described and written of as being "the same as time study," or "a part of time study." Motion study, as used here, means the science of recording motions, of which "time" is but one of scores of variables.

34. The psychologists have done more than point out the failings, incompleteness and mistakes of the stop watch time study methods. They have indorsed the scientific method of recording the surrounding conditions simultaneously with the motions and the times, with instruments of precision, free from personal error, leaving the motion study man's eyes, mind and attention free for coaching the observed man, that his record may more nearly approach the one best way and be more worthy of the care, skill and film that are used to make the record. They have used such records in their investigations of behavior as affected by habit, fatigue, power of decision and other variables affecting the learning process and the achievement of greatest outputs with least effort.

35. Meanwhile, scientific management has been sneered at and has been the object of constant joking and scorn, because it is perfectly obvious to any scientist that, as often practiced, it has little claim to be called scientific, so long as it depends for its fundamental data upon "averages" of inaccurate stop watch time study that does not record the surrounding conditions at the time that the records are made.

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[19] "Shop Management," A. S. M. E., paragraph 386, Harper, page 169.

[20] "Applied Motion Study," Chapter VII "Motion Study for the Handicapped," pages 25-33.

[21] We have always been and are still unalterably opposed to secret time study and have never practiced it nor permitted our employees to practice it, although our telemicromotion apparatus will record a man's motions and the times a mile away as easily as a "close up."

36. Educators also, especially those interested in visual education, and lately those interested in the education of the crippled and blinded, and all other types of the handicapped, have appreciated the emphasis on the *accuracy* of the original record, the *usefulness* of the standard method of getting the one best way to perform the work, and the *teaching value* of the method embodied in these standards.

37. The indictment of education against the unnecessary inefficiency of stop watch time study has not yet been fully made. It is the most serious of all indictments, and will cover not only the things that have been done that should not have been done, but also the things that have not been done that should have been done.

38. Stop watch time study has, to all effects, recognized the validity of the psychological criticism. This may lead to the anticipation of further educational criticism and to changes in method that will tend to avert this, and also criticism from the ethical standpoint. Another present need seems to be a realization of the value of criticism from the standpoint of the science of statistics, which we present here.

39. This indictment is made primarily upon the use, throughout the entire process of making and using stop watch time study, of that which is "average." In the first place, it is customary to make records of the "average worker" or "one slightly above the average," and some advocates of the stop watch recommend making records only of the indefinite "first-class man." As a matter of fact, there is no such thing as an "average man," and if there were it would require much research to determine and to locate him. The border lines of defining the "first-class man" are as indefinite as the location of a rainbow. There is but one type of worker that is fixed, at least for the time being, that is *the best man obtainable at the time,* at that particular kind of work. This may in reality be represented by the synthesized work of several of the best workers. The synthesis of a best method is obviously impossible with the stop watch methods or with data taken on "average" workers. Any data taken from observation of an "average man" are sure to be inferior to the best method used by the best man obtainable. All scientific methods are based upon the utilization of the best obtainable, and an ideal to come to; such an ideal obtained from the most skillful, and not from the average, is always an inspiration for further attention, effort and learning to everyone—apprentices, learners, workers and teachers. The great principle of having an ideal of method toward which each one is to approach, as near as his capabilities will permit, is entirely lost by those who depend upon averaging times or methods which have been inaccurately observed and inadequately recorded and then averaged.

40. It must here be emphasized that having an ideal of method is something entirely different from having an ideal of *"speed with which work is to be done,"* or as it has been sometimes worded, *"the time that it takes to do work."*

41. The allowance to be figured for calculating the task is more easily figured with relation to the standard man[30] or best man obtainable at that particular kind of work—the most expert worker—than with relation to an unscientifically selected worker, who is guessed to be an "average man" or to be an indefinite "first-class man."

42. It may be possible that in some organizations the "average worker" is still selected for such observation, not because he is supposed to be easy to find, but because it is erroneously supposed that workers will approve of the "average" in efficiency being observed, as typifying what is to be expected of them. The students of labor problems, both in and out of the ranks of labor, realize today that education of the worker is the greatest need, whether or not he will participate in the management, and no form of education for the worker has surpassed that of showing him the micro-motion study records and the simultaneous motion cycle charts of the methods of the best man obtainable. All workers have far too little time to study, and therefore they do not desire to waste time studying the methods of the "average man," or anyone else other than the best. Neither is it necessary that observations be made of the "average man," nor of the man "a little above the average," nor of "the first-class man" for the purpose of setting proper and achievable tasks and in order to make proper planning programs, because, regardless of the source of the data, the task, or quantity of the program, must be set at that point which is achievable by the worker who is actually put to work at it, or the task idea in management will do more harm than good. As a matter of fact, the workers in this country and in the countries abroad, as they come to appreciate the value of real standards and the accompanying benefits to them from better management methods as a means of increasing the purchasing power of the results of their labor are *demanding* not

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[30] "Psychology of Management," page 152.

only that they themselves shall be allowed to take part in the investigations as well as in the application, but they are also in favor of the highest degree of accuracy in the recording process. There has not been an instance in our experience where workers have failed to appreciate the accuracy of the recording devices, when this was brought to their attention, nor have we failed to have them realize that the methods which are being recorded ought to achieve the same degree of perfection that the recording devices have already reached. Furthermore, it should always be realized and emphasized that the primary interest is in the problem of obtaining correct fundamental data, in such form that they can be transferred to and used by others and not merely data for temporary, makeshift task purposes, but for a permanent plan of cumulatively perfecting standards, ever holding and improving upon the best way known.

43. This criticism of the use of the "average" is sustained by the laws and best practice of the science of statistics. Statisticians also lay down certain fundamental requirements for proper records, which stop watch time study does not meet. We quote from several recent books by authorities on economics and statistics, who maintain that in order to be worth while:

44—1. There must be the greatest care in recording *quality*. King, in his "Elements of Statistical Method," page 32, section 17, says, "One of the shortcomings of statistics is that they do not always bear on their faces the label of their quality." It is evident that stop watch time study fails in this respect.

45—2. Accuracy is imperative.

(King, page 33, section 18: "The value of statistics depends primarily on the accuracy of the figures.")

(Horace Secrist, "An Introduction to Statistical Method," page 27: "The difficulty is not necessarily one of error in reporting (yet undoubtedly this is an important factor), nor in the accuracy with which such facts *might be determined*, but rather with the accuracy with which they *are* determined under the conditions of collection.") We have noted that it is impossible to take accurate records of small units by the stop watch method; in fact, the smaller the units the greater in proportion is the error, yet the scientific method always demands the examination of the smallest units possible.

46. Also King, page 76, section 46: "The total can be no more accurate than its most faulty item." And again, King, page 77, section 47: "The absolute accuracy of a total can be no greater than that of the most inaccurate item composing it." Therefore, since the original data are inaccurate, stop watch time study cannot hope for accurate results, no matter how it handles them or how it "works up" the observed times.

47—3. Individual differences must be noted. (King, page 35: "Statistics from the very nature of the subject, cannot, and never will be able to take into account individual cases. When these are important other means must be used for this study.") "Individual cases" in time study are important, for from the study of them and investigations of the causes we often find clues to better methods.

48—4. No mathematical accuracy will compensate for inaccuracy of fundamental data. (King, page 70, section 44: "An exceedingly common error is to give to figures a large degree of fictitious accuracy which arises simply from some mathematical operation. One must guard against such fictitious accuracy whenever numbers containing decimals or giving a decimal as the results are multiplied, divided, raised to a power or the root extracted.") We have already noted the mathematics of determining times, and note here the dangers in their use.

49—5. There is no assurance of increasing accuracy by increasing numbers of observations, if the method is not accurate. (King, page 62, section 38: "It is better by far to have a small number of correct samples than to have a large number of incorrect ones.") Not even the accumulation of a large amount of data will make stop watch records accurate even ultimately. Merrick states that his curves, on page 17 of his book, are "based on the data from a vast number of time studies," but it was non-recordable, inaccurate, unsynthesizable data of the stop watch method.

50—6. The unit to be observed must be accurately determined. (King, page 46, section 25: "Not only must the unit selected be defined with precision, but it must also be of such a nature that it may be correctly ascertained.") This is impossible with stop watch time study.

51—7. The greater the number of items observed, the more danger, if the records are not accurate. (King, page 75, section 45: "When the number of items is larger, compensating errors, if relatively small, are negligible, but, on the other hand, cumulative errors always seriously affect the accuracy of the total or the average.") This shows that the faith put by the makers of stop watch time studies in *number* of observations is not well founded.

52—8. The *average* is not only *not* accurate, but is a dangerous tool. (Secrist, page 28: "Do not rush headlong into the use of averages. They are commonly but vaguely understood, and it is the particular function of the statistician to adopt that caution and circumspection in the use of numerical facts which the seeming exactness of his tools appear not only to suggest but to make imperative." Again Secrist, page 22: "As caution and analysis are necessary in the employment of averages, no discrimination and judgment are necessary in assigning importance to them when used by others.")

53—9. It is necessary to stress the importance of the *exception*. (Secrist, page 29: "Frequently an exceptional instance which would be ignored in the use of the mode is that particular instance in which one has greatest interest.") We have noted that stop watch time study discards those instances which are "guessed" to be "abnormal." If they were normal enough to record, they should not be discarded merely because they differ from the average. It must also be remembered that these very same so-called "abnormal" times may record the exceptional instances, which are the most desirable to perpetuate. When such times are abnormally high they may be caused by methods and conditions of habit which should be broken and discarded and pitfalls to be avoided.

54. Many more quotations by leading authorities on statistics can be furnished but these few quotations serve to indicate how completely the statistical method can demolish any claims of accuracy or of the scientific method of stop watch time study.

55. The basic criticism of stop watch time study is that the inevitable interference of the human element, when the stop watch is read while it is running or pressed to stop or start, prevents accurate observations and records. Even if one record should happen to be accurate, there is no chance to recognize it, and no chance to inspect, check or repeat the work as then performed, because the surrounding conditions are not also recorded.

56. It must not be supposed, however, that stop watch time study has no uses, for it is much better than nothing. The use of the stop watch also furnishes admirable training for the young management engineer, and it is a necessary, though not an indispensable, part of his education. Without actual experience with the inaccurate stop watch method he will never be able to appreciate the possibilities of interchangeability of micromotion data and their value at any time later to anyone who is either searching for knowledge regarding the best that has been done, or is interested primarily in finding the one best way to do work. In no other way can he realize that micromotion study is less expensive than stop watch time study. We advocate this training, and have three different kinds of watches made exclusively for us, which have black faces and white hands to cause less fatigue, and which, while intended primarily for micromotion study, are also much better adapted to stop watch time study than any others.

57. We believe these types of watches to be the most efficient of their kind, although their records, when not photographed, cannot compare, of course, in accuracy with those made by the micromotion process.

58. Only through personal experience with the difficulties and inaccuracies of stop watch time study can the young engineer come to appreciate the need for a more accurate method, and the benefits of basing the *art* of time study on the *science* of taking times.

59. It is the right of the young men in this society to learn the science of taking times. It must be realized that loyalty to *principle* does not imply loyalty to *technique*. All advocates of scientific management object to restricting its evolution, especially along lines that insure its acceptance as a science.

60. The young men have studied and practiced stop watch time study faithfully and loyally. They deserve something better, more accurate and more valuable. They deserve the best! It is our duty to warn the young men of the Society to accept no statements regarding any science without definite proof, unless the scientific method has been used in deriving the facts. The young men must think for themselves. They must learn to place emphasis properly, and to realize that the stress that has been laid on "the time that it takes to do work" or "the proper rate of speed at which work should be done" or "time study for rate fixing" in no wise dwarfs the necessity for finding the one best way of the best available.

61. The young men should also be warned that, when they hear criticism about the "high cost of accurate photographic time study," they should remember the cost of the scores of years of stop watch time study records that have been totally abandoned because they were so inaccurate that they did not serve as a basis for cumulatively improving standards, and did not include records of surrounding conditions. In money cost and in cost of time the more accurate methods are the most efficient and economical.

62. It is not our aim in this paper to present at length criticism of stop watch time study, or to describe in detail all the advantages derived from the

more accurate method of micromotion study, which includes accurate timing as an integral part and an important by-product of the quest for fewest, most efficient and least fatiguing motions. We do not need to point out the utter uselessness in executive's theatres, foremen's meetings or workingmen's lecture rooms, of stop watch time study, and the possibilities of the utilization of micromotion study film as the basis of craft education and improvements in methods which come through the suggestion system.

63. The part played by micromotion study in determining best results of the three-position plan of promotion will be discussed in one of our later papers.

64. We aim to present for your consideration the objections to the records and devices from the abstract and scientific standpoint, calling to the attention of this Society especially the objections from the statistical side. We desire to emphasize the effect upon planning and control of using data scientifically derived by instruments of precision instead of the non-method-recording stop watch methods.

65. It must not be forgotten that, as Dr. Taylor said in "Shop Management," "time study is an *art.*" He hoped that it would be based on a science, and be listed as the first of the four chief duties of the management, that "they develop a science for each element of a man's work which replaces the old rule-of-thumb method."[23]

66. In "A Piece-Rate System," written in 1895, he said he hoped that there would be books of accurate data that would settle once for all and that would describe methods of making, recording, tabulating and indexing time observations, since much time and effort are wasted by the adoption of inferior method."[24]

67. He considered what he said so important that he wrote it again, in the same identical words, in "Shop Management," in 1903, eight years later.[25]

68. The micromotion method is the only method that fulfills all the requirements that he makes. This method has fought a hard fight and it has won by reason of its scientific accuracy, its records in revising the best that the stop watch had done, and by the co-operation it has secured from the workers everywhere, without exception. It is indorsed today by economists, educators, psychologists and workers, and is more and more being accepted by managers, even those who have advocated and practiced the use of the stop-watch.

69. We had the honor to offer the use of this method to Dr. Taylor himself, practically as soon as the devices and methods of measurement were perfected, and we wish to go on record here as having offered this method for use by this Society and the management engineering profession in general.

70. We repeat this offer at this time for the following reason: We know that the stop watch method is now being subjected, and will be increasingly subjected, both in this country and abroad, to the most careful scrutiny. This examination is being conducted not only by enemies of scientific management but by its ardent friends and advocates, who feel that its future depends upon its ability to live up to its claims of being a science. The sooner this state of affairs is realized, and the sooner that this Society prepares to meet criticism, and to justify belief in its principles and practice, the more satisfactory will be the outcome.

71. As advocate of real science in management; as interested in the progress of the art of management; as vitally concerned in the future welfare of this country, and as ready to fight for it industrially as in war; as engineers trying to do our bit in the problem of the elimination of all kinds of human waste and for better management, we, therefore, feel compelled at this time to indict stop watch time study as having outlived and extended beyond its field of usefulness; as having failed to co-operate with micromotion study; as having failed—and in some cases deservedly—in obtaining the hearty co-operation of the workingman; as having failed to put into the hands of the workingmen and the trade and manual-training schools fundamental data regarding craft knowledge and craft skill, and as having failed to furnish interchangeable data relating to time study elements usable in synthesizing the one best way to do work. We make this indictment before this Society with the feeling that the Society should estimate and measure the two methods submitted, impartially, carefully and with the aim of fostering those methods which have the highest scientific value. We should have been glad to have had this indictment presented before the Society by the advocates of the stop watch method, for some of them are now coming to see the importance of accurate unit times. It may seem to some that the economists are the ones who should have presented this indictment. Unfortunately, however, these economists also, in spite of our previous re-

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[23] "The Principles of Scientific Management," page 36.

[24] Paragraphs 67, 68.

[25] A. S. M. E. edition, paragraphs 390, 391, Harper edition, page 177.

marks on this subject, have so delayed their presentation that we can no longer reserve for them this opportunity for priority.

72. We have great faith in a happy outcome of this indictment because of the complete success resulting from our previous unsupported attack from the psychological standpoint, which we hope and trust to see repeated here.

73. For permanence and maintenance, planning, control and other functions of management must be founded on cumulatively improved standards derived from correct motion study and time study facts, the handling of which in accordance with the laws of engineering and psychology constitute scientific management.

74. We had the honor to suggest and to start this Society by calling the first gathering of management engineers. This gathering was the first meeting of the "Society for the Promotion of the Science of Management," the first society of management engineers. The name was afterward changed to the "Taylor Society, a Society to Promote the Science and the Art of Administration and of Management." It behooves this Society to determine at once the stand which it desires to take on the subject of accuracy of fundamental data of management and to decide whether it intends to live up to its name as a "Society to Promote the Science of Management"—*or not.*

II. A DEFENSE OF THE STOP WATCH

By Carl G. Barth[1]

1. The object of time studies, as understood by myself and other direct disciples of Mr. Taylor, is to determine a *fair time to allow* a worker for the performance of a task to entitle him to a certain to-be-agreed-upon amount of compensation for the performance of the task within the time thus allowed, and with the additional understanding that, if he performs the task in less than the time allowed, he will receive additional compensation as measured in terms of time taken, in accordance with some rule or other; while, if he falls short of performing the full task within the time allowed, he will suffer a corresponding reduction in his compensation.

2. Because of the diverse absolute abilities of the workers who may have to be used on similar jobs, and also because of the variation in the ability of each individual worker from one day to another, yes even for different periods during a single day, it is hardly conceivable that two time-study men, however well equipped by training and experience and with physical means, would arrive at exactly the same time allowance for any job each might in turn be independently assigned to study. And still, the time allowance of either would undoubtedly be fully satisfactory for use in establishing a *fair* contract between the worker and the management, though the two would not be identical.

3. For this reason, and for the further reason that the same worker does not spend exactly the same time on the same operation every time he performs it during even the same short period of observation, there would certainly seem to be a limit to the degree of accuracy of observation and time recording (whatever the instrument of measurement) that would be of substantial help in reaching a satisfactory time allowance for a task.

4. As a consequence, I cannot agree with the Gilbreths in their condemnation of the use of the stopwatch as absolutely unscientific in making time studies, merely because they have invented and use a far more accurate time measuring device than the stop watch.

5. Of course it would be preposterous to maintain that, even with a somewhat uncertain final quantity to be measured, it would not always be desirable to employ the most refined measuring device obtainable; but with the numerous difficulties that beset the management, or industrial engineer—or what else you choose to call the man usually responsible for the time-study work in an industry—this individual has again and again to be satisfied with equipment that is not what he considers the very best, and thus to content himself when able materially to improve matters around him, even though his accomplishments oftentimes fall far short of what he knows to be possible of attainment, and of what he had aimed at and had hoped to do.

6. And in this he is no different from many a recognized scientist who, either because of his own poverty or that of the institution with which he may be connected, is unable at once to secure the very latest and best equipment for his research work. Thus, for instance, all astronomers cannot have the equal of the most powerful and finest graduated telescope; and many a fine biologist may for a time have to content himself with a microscope that is not the best obtainable; and still, nobody would assert that these men

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[1] Consulting Engineer, Philadelphia.

could not be scientists of the highest order merely because of these handicaps, and this in spite of the fact that they are after the discovery and measurement of absolutely definite objects.

7. To my mind it is not so much the *means* as the *method* of using these, that determines scientific as against unscientific procedure.

8. Now, the stop watch is a cheap and hence readily obtainable means by which time studies can be made, as against the Gilbreth motion-picture machine with its beautiful way of recording very fine subdivisions of time simultaneously with the events photographed, but as the latter cannot—any more than a stop watch—automatically pick the most suitable in a group of workers to which to apply it, or overcome the variations in the performance of any worker selected, I cannot see that it can do much more for us than to measure more accurately the elementary operations performed by the particular worker photographed.

9. I venture to say this, though the whole subject of time study has never been more than a side issue with me during the twenty years I have been engaged in the exploitation of scientific management, whereas Mr. and Mrs. Gilbreth have applied themselves to the subject in a most ardent and industrious manner, for several years past. However, I have reasons to believe that their studies have been mostly connected with repetitive work implying exceedingly minute motions and individual time elements, and practically no machine operations as most of us understand them. On the other hand, practically all my work and all the time study work of Mr. Merrick, whose book on this subject and my preface to the same have given rise to this "Indictment of Stop Watch Time Study," has been connected with all around machine shop work, in which the time of machining a piece of work sometimes exceeds by many times the time the operator applies himself directly.

10. With us, therefore, it has so far been more a matter of the study of the possibilities of the machine and the surrounding conditions that are independent of the particular operator, than of the operator himself.

11. Our gains have consequently come more from the re-speeding and often re-building of machines, the institution of improved tool rooms, and so forth, than from the subsequent time studies made of the manual operations involved, though no effort has been spared in also improving these by the elimination of useless motions and other waste efforts, which in connection with the ordinary run of machine shop work that we have encountered, is more a matter of past general experience and the commen sense that goes with it than of a time study comparison of different motions.

12. The final time study of the operator, with the stop watch as our only means, even if not what it might have been with a more accurate time-recording device, we feel, therefore, has been fully accurate enough in a practical sense; for a more refined way could not, as a rule, have enabled us to gain more than a small percentage of purely theoretically more correct task time allowance, which, because of the unfortunately high precentage of special allowance we are compelled to make on the preliminarily determined machining time from the feeds and speeds selected, can never, in this kind of work, be more than making the best of a troublesome matter.

13. This high percentage of allowance on machining time has been forced upon us by the electrification of machine shops, for electrically driven machines are far more subject to speed variations beyond our control than are steam-engine and belt-driven machines whose belts are systematically cared for, and which accordingly require only a small special percentage of allowance on the machining time alone.

14. In referring to their motion-picture machine the Gilbreths also made the statement that their pictures preserve for all times the exact conditions under which a job has been performed. I remember well a picture Mr. Gilbreth exhibited of a turret-lathe job the only time I have heard him speak on the subject, at which time he also made a similar statement in regard to that particular job. At that time the statement impressed me as being a very extravagent one indeed, though perhaps momentarily excusable on the part of an enthusiastic inventor. I could not see then, nor can I see now, how the condition of repairs of the machine, the shapes and correct settings of the tools, the spindle revolutions and the feeds, etc., could possibly be observed even by the application of the microscope to the films themselves. In fact, I could see nothing whatsoever in that particular picture, except the minute divisions of the accompanying timing device.

15. By this I do not mean to say that similar statements may not be, at least approximately, correct with reference to many similar pictures taken of jobs of a totally different nature, and I do not wish to be understood as wanting to underestimate the achievements of Mr. and Mrs. Gilbreth; but I cannot help

believing that their apparatus and methods are not unqualifiedly to be recommended for exclusive use in time studies.

16. Mr. Taylor himself in the following quotation made by the Gilbreths from "Shop Management"—"What the writer wishes particularly to emphasize is that this whole system rests upon an accurate and scientific study of 'unit times,' which is by far the most important element in modern management"—spoke as the enthuiastic originator and performer seeking a following. It did not take me long to learn to make allowances for the enthusiasm and not to take it quite so seriously as all that; just the same as I am not taking the claims and statements made by the Gilbreths quite so seriously as their ardent and persistent work naturally has prompted them to make these. Yes, as has universally been my experience through all these many years, the preliminary and preparatory work and reform that I have had to do to put a concern in a condition for worth-while time studies and task setting of any kind, has been more effective of waste elimination and all around good than the work resulting from the subsequent time studies taken; and I can make the positive assertion that this has not been due to the fact that a stop-watch was used and not a more refined timing device.

17. In regard to the criticism of the manner in which Mr. Merrick chooses each of his final unit times from the records made by his stop watch studies of a great number of each of these, I cannot see but that it is as scientific as a majority of determinations made in other fields of engineering, except when pure mathematics alone is involved. Such determinations are in the end based on certain assumptions that we know to be only approximately correct. Thus we never know the exact ultimate strength or elastic limit of any material we intend to put into an engineering structure; but we nevertheless assume something definite,—that is, we guess, and trust to luck that our guess is near enough correct to serve for practical application in a theroetical formula the correctness of which is even open to some suspicion, but which represents the latest and best available to us.

18. Again, in calculating the weight of a complex structure it is considered the best practice to calculate as closely as possible, on a purely assumption basis of the exact density of the materials implied, the weight of each of its constituent parts, and only, if at all, to round off the final figures of the sum of the individual weights calculated for each kind of material and of the entire structure.

19. Viewed separately each individual weight of such a sum looks indeed as a preposterous pretense at an ability to predetermine with precision that which is fully realized to be a mere approximation. In the final analysis it all means only a consistent manner of guessing at the value of each part, and trusting to the probability of a partial compensation of the individual errors, to give us a relatively more correct weight of the structure as a whole than the weights arrived at for the individual parts. And I surely cannot imagine that anybody would contend that the individual times consumed in performing motions by human beings are more nearly constant than the weight of materials produced from engineering drawings and specifications, or that a small error in predetermining the former as a basis for a fair contract between a worker and his employer, is more serious than an error in the predetermination of the latter as a basis for a fair engineering contract.

20. But when it comes to the criticism of attempting to use a stop watch for the determination of operations so short that probable error in the observation and recording of its time value may equal or even exceed the time value, it certainly is more than justified; and we are all greatly indebted to the Gilbreths for having persisted in their efforts—apparently long since crowned with eminent success—to devise instruments and methods which make the measuring of such minute elements of time possible.

21. They have thereby opened up a whole new world for scientific investigation, comparable perhaps with those that the microscope and the telescope each did, as compared with the circumscribed field of the simple magnifying glass.

22. My contention is meant to be only the equivalent to claiming that the magnifying glass has still its legitimate use along with the microscope and the telescope. In fact, when occasionally a time element is met with which is too short for even an approximate determination by a stop watch, along with time elements so determinable to a satisfactory degree, all we have to do is to fully realize this, and then either neglect it altogether or let a guess at it go in for what it is worth; just the same as it does not make any appreciable difference in the total weight of a large structure, if we either absolutely neglect or overestimate the absolute weight of one or two small parts of it.

23. One reference I think the Gilbreths might well have left out in their indictment of the stop watch, is the fact that, when first used for time studies, it

was often concealed and used in observing a worker clandestinely; for they also admit that this is no longer being done, and I will add, has not been done since I became associated with Mr. Taylor. Hence that statement can have no other effect than to prejudice the reader against the stop watch in an unnecessary and unwarrantable manner.

24. So far as my knowledge goes—with one single and deplorable exception never likely to be repeated—no direct disciple of Mr. Taylor has ever timed a worker without heeding Mr. Taylor's injunction not to do so without properly preparing the way and obtaining the full consent and cooperation of the worker, a thing that is absolutely independent of the kind of timing device used. And still, we must admit that the Gilbreth motion picture-machine precludes even the possibility of clandestine observation; but I cannot see that it necessarily implies the consent and full cooperation of the worker.

25. And now, finally, let us turn to the very opening paragraph of the paper under consideration, namely: "Planning and control and all other functions of management depend first, last and all the time upon the standards upon which they are based. These standards, in turn, depend upon the fundamental data from which they are derived. The fundamental data for determining standards are obtained by motion study and time study," and see if we ought not also to accept that clear and confident statement with reservations as in fact already implied in my previous contentions.

26. Planning in an industry, while the very essence of scientific management, can never be a very exact thing for short periods at a time, for modified requirements by customers and unforseeable accidents to materials and machines, etc., constantly upset our forecasts; but with our plans before us in a very tangible manner, we can re-cast our plans as often as such disturbances occur, somewhat in the same manner as railroad schedules are always subject to accidents and disturbances due to adverse weather conditions.

27. In fact, I know of a concern that inaugurated a scheduling system, more than a generation ago when the idea was a new one, but soon gave it up, not because of the difficulty of estimating near enough for the purpose, from the piece rates in use and the limit put on the worker's earnings, the time each job would take; but because of the constant upsetting brought about by time lost because machine castings contained hidden defects that such partial machining alone could disclose. By the present time, however, we have learned not to let such matters discourage us completely; we resolutely re-arrange our schedules every time such difficulties occur to a greater extent than the time "safety factor" adopted allows for, just the same as the railroads, whose inefficiency we are all wont to deride, never for a moment consider giving up their schedules no matter how often or how badly these become deranged. On the contrary, under such conditions all the available efforts of a railroad management are for the time being concentrated on re-establishing the schedule.

III. A DEFENSE OF THE STOP WATCH

By Dwight V. Merrick[1]

1. There is very little that I can add to what has already been covered by Mr. Barth.

2. Mr. Gilbreth in his remark emphasizes that by his motion picture method he is able to show an operator a one best way of performing his work by a study of a picture taken on the best operator. Mr. Gilbreth further emphasizes that the time element is only secondary and can be used if desired.

3. There are many instances where feed and speed data are far more important factors than the handling time data, and then a study of a picture of a one best method performance becomes secondary. In such cases timing with an ordinary stop watch is close enough. To illustrate: at Watertown Arsenal I set times on jobs covering as much as 120 hours with very little time study preparations, and when I told Mr. Barth of this he expressed considerable surprise; but when informed that the greater portion of the job was machine time, dependent on the feeds and speeds which were determined by the slide rule, he realized that the handling time was an insignificant factor. In some instances this handling time was as low as five per cent of the whole, and in most cases on the large machine tools, on long jobs, it averaged about ten per cent.

4. This was also the case at Bethlehem in the early days. There the rates were set entirely by the slide rule and a small allowance made for handling time.

5. In recent years my work has often been of such a nature that I have felt the need of a more accurate time-measuring device than the ordinary stop-watch. This work was of a highly repetitive kind and required intense application on the part of the observer to record his readings, as the time of performance of each operation was of short duration.

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[1] **Consulting Engineer, New York.**

6. For such work it appears to me that there is no better device at present than the Gilbreths' motion picture machine, as it can be made to illustrate by a picture a best method of performance, and at the same time register the time of performance of each elementary motion.

7. Nevertheless, I do not believe that it is the panacea for all ills as claimed by Gilbreth, for there is a useful field for both methods. I am thoroughly convinced that for ordinary, practical purposes the stop watch will continue to be the most convenient time-measuring device.

IV. A DEFENSE OF THE STOP-WATCH

By Robert T. Kent[1]

1. The speaker is in a somewhat peculiar position. He was associated with Mr. Gilbreth in the development of micro-motion study; in fact he was the first person to whom Mr. Gilbreth confided his invention. He also had no little part in the preparation of Mr. Merrick's book on time study. He is, therefore, in a position to speak with some measure of authority upon both phases of the subject.

2. The speaker at once recognized the value of and has been from the beginning an ardent advocate of Mr. Gilbreth's method of time and motion study for certain classes of work. He believes that the method offers a great advantage over all previous developments for absolute accuracy in the recording of time and the transference of skill. For motions or cycles of motions which are so short and follow each other with such rapidity that it is difficult or impossible for the eye to follow, there can be no question but that the motion picture camera study is in a class by itself.

3. On the other hand, there are certain classes of work for which it is ill adapted. There is time study and time study. Certain studies can be made, with all accuracy needed, with no other instrument than an eight-day clock. Other studies will require instruments of greater refinement — an ordinary watch or possibly a stop watch. For still others, the micro-motion camera is the only device suitable.

4. Time study is simply a method of measuring time. The use of any instrument for time study is exactly on a par with the use of a two-foot rule or any other measuring instrument for the measurement of lengths.

If we are to cut a piece of wood whose length will be close enough if it is within one-quarter inch on either side of a given dimension, a carpenter's two-foot rule will be a sufficiently accurate measuring instrument for the purpose. Having such a rule available, we should be foolish to use a machinist's scale reading to the sixty-fourth of an inch and to attempt to measure that closely. On the other hand, we should be equally foolish to attempt to measure with a two-foot rule, or even with a machinist's scale, a fine job in the lathe which has to be turned with a limit of error of plus or minus two one-thousandths of an inch. We should use the micrometer. Further, if we were making a reference gage, whose accuracy had to be within two or three one-millionths of an inch, no measuring instrument would be suitable except an interferometer. As it is with the measurement of physical objects, so it is with time study. In each case we must use the tool best suited for the job in hand, whether it be the two-foot rule or the interferometer, the stop watch or the micro-motion camera.

V. MAKE TIME STUDY OPEN AND ABOVE BOARD

By Morris L. Cooke[1]

1. Mr. Taylor frequently expressed himself to me as being absolutely opposed to secrecy in time study when the results of such study were to effect in any way the wages to be paid to the individual on whom the observations were to be made. This of course was but one application of a broader principle, i.e., that we should never seek to induce or compel any man to do anything against his will or rather without first having gained his active consent to what it is proposed to do. Compulsion except in the matter of forcing people to live up to bargains freely entered into was abhorrent to Mr. Taylor as it is to any red-blooded man. On the other hand, Mr. Taylor felt that it might be entirely proper to make time studies on people whose interests were to be in no wise affected by them and without their knowing that it was being done. This saved the time required for explanations. I recall that this method was followed in the making of some of the observations needed for "Concrete—Plain and Reinforced" and "Concrete Costs." Such observations were made in the interest of accuracy of statement in the text and were of no interest to the employer on whose work the observations were made or

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[1] Mechanical Engineer, New York.

[1] Consulting Engineer, Philadelphia, Pa.

to his employees. In fact the employer knew as little about it as did the workmen who were unobtrusively not to say secretly observed.

2. But I believe the time has now arrived when the Taylor Society should decide that it is unwise to make secret time studies under any circumstances. Under the best of circumstances such practices are likely to be misunderstood. Secrecy is generally out of harmony with the spirit of scientific management. I happen to know of more than one shop where under one excuse or another secret time studies are being made. I am thankful to say that I know of no member of the Taylor Society who makes secret time studies. If we can declare studies so made as unprofessional then the possession of the paraphernalia that goes with them becomes taboo. It would be a good thing if someone would invent a stop watch that barks every time it is taken out of the pocket. Both the stop watch and time study are of a piece with the industry of the future; the less mystery there is about them the more promptly they will come into generally accepted use.

VI. STANDARD TIMES FOR STANDARD "WORK ELEMENTS"

By Thomas W. Mitchell[1]

1. In addition to ordinary time study there is another important purpose for which the Gilbreth micro-motion recording apparatus should be very useful, namely, for the purpose of determining the degree of effectiveness of alternative methods and to determine the best basis on which to select from the mass of varying readings the standard time for an element.

2. It is remarkable in a profession that advocates scientifically determined standards that the very methods of determining element-time standards even when the same instrument, the decimal watch, is used, have not been standardized. Mr. Sanford Thompson uses one method, Mr. Merrick a second, Mr. Knoeppel a third and other practitioners use other methods. Element data obtained by one is not usable by the others. They cannot all be best.

3. It is a common experience in making studies to obtain on successive units of work a number of different readings for the same element. These variations may be produced by three different causes. First there may be a variation in the amount of work contained in the element. Thus one leaf sight back may be a thousandth part of an inch wider than another, creating a greater difficulty in either inserting it into or extracting it from a drilling jig. Second there may be a variation in the worker's performance due either to a greater or less dexterity and speed from piece to piece or to variation in the constituent motions. Third, the variations may be due to errors in reading the running watch.

4. To the observer with the running watch these causes are concealed. A photographic record, however, will eliminate the observer's errors, show the variations in motion combinations and sequences and even many of the variations in the amount of work. Simultaneous studies made by first class decimal watch observers, by observers with H. H. Williams time study machine and by an observer with the Gilbreth apparatus on the same operations and same operators should go far toward giving us criteria whereby to ascertain these causes by an internal examination of the study, and lead us to a standardized procedure and method.

5. Another kind of research that probably would be helpful would be a series of "before and after" studies, i.e. time study made upon experienced operators before they are put on piece work or on task and bonus and time studies made upon the same operators and same operations after they have been put on piecework or task and bonus long enough to have adjusted their speed to the new incentive. A comparison of the readings obtained for the same elements under such before and after conditions should shed a flood of light upon the question of what is the proper basis on which to select the standard time for an element and of what constitutes a satisfactory time study.

6. I still have faith in the idea that out of the myriads of operations there are comparatively few classes of work elements, just as all thought can be expressed by various combinations of less than a hundred written characters. I have had startling success in many instances in closely predicting the time of composite work elements by synthesizing the time I had in mind for such constituent elements as "pick up," "put down" and the like. However, very little progress has been made in this direction. One reason for this is that most of these constituent elementary motions are very short, some of them as fine as .008, .005 or even .002 min-

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[1] Consulting Engineer, Philadelphia.

ute. These cannot be timed directly by the running decimal watch, and the percentage of error in measurement by indirect methods is so large as to vitiate the results. For such a study the micromotion study apparatus is excellently adapted. I believe that by going at this subject persistently and systematically in a few years we could have for each of a hundred work elements a graphic chart, like those already attained for many elements at J. H. Williams Drop Forge Works, showing the range of the time of the element according to the size, shape, position and the like of any object to which it applies. Then we could realize our ideal of being able to analyze a new prospective job, write an instruction card for it, apply elementary time data and set a performance standard for it without leaving the desk in the planning department.

VII. TIME STUDY AND HUMAN STANDARDIZATION

By Reynold A. Spaeth[1]

1. In a paper delivered before the New York Section of The Taylor Society on December 16, 1920 by Mr. and Mrs. Frank Gilbreth, an indictment was advanced against stop-watch time study as it is customarily practiced. The validity and the scientific value both of the method and of the results were criticised. The method of stop-watch time study is believed by the Gilbreths to be too crude and they suggest substituting their motion picture technique for it.

2. After a careful reading of the Gilbreth's paper it seems to me that they have lost sight of the fact that the problem of time study is not one involving extraordinary accuracy in measuring time. In their motion picture technique they have concentrated upon a method that will give them a high order of absolute accuracy for the particular function measured, that is, motions in time intervals. This, however, is not the real problem.

3. In my opinion the stop watch, instead of being inaccurate, is already far too accurate. It is, in fact, of a different mathematical order of accuracy from that of the final result. The statistical arguments advanced by the Gilbreths are entirely correct, but they do not apply to stop-watch technique itself. The reliability of statistical data obviously does depend upon the accuracy of the individual components which constitute the final result. Most physiological experiments, however, probably have an error of about five per cent. Some of the real sources of serious error in stop-watch time study are unknown variables as allowances for delays and fatigue, variability of incentives and of individuals, and the mutual suitability of job and man—to mention only a few.

4. The time-study man's job is to set a fair wage on the basis of his observations not only of time intervals, but with the additional of allowances for fatigue, delays, etc. The final result, therefore, whether with a stop watch or with a moving picture technique, is made up of a combination of some very accurate measurements and some guesses. Consequently, your best guess necessarily determines the order of accuracy of the final result. If a chemist has to weigh a definite quantity of a particular substance and takes one fraction and weighs it to five decimal places on an extremely accurate chemical balance and then takes the remainder and "hefts" it with his hand and guesses it to weigh about a pound and a half, the final accuracy of his result depends not on the weighing that he did on the chemical balance but on his ability to guess accurately—whether in other words the other fraction really weighs a pound and a half or not.

5. It is important to bear in mind that the Gilbreths face exactly the same group of variables as the stop-watch time study man when they come to apply their observations on "the one best method" to other people than the particular expert studied. In other words, although the average man is not believed to exist by the Gilbreths, nevertheless it is average men and not exceptional experts with whom we are forced to work in practice. Whatever inspiration may come to the average workman from observing a five foot piece of film with a magnifying glass, I am frankly skeptical just how much such a study will contribute toward the learning of the expert's technique by the average workman.

6. I do not wish to be misunderstood in this criticism. As a research method and as a permanent record of the best way to do work there is much to be said in favor of the fascinating and highly ingenious technical appliances devised by Mr. Gilbreth. The possibility of synthesising a working method from the performances of different individuals is at least a theoretical argument in favor of the motion picture technique. In certain extremely

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rapid processes it may doubtless find an application also. However, when we are asked to abandon the stop-watch time study method and adopt the motion picture technique with the object of improving the accuracy of the final result, I believe this to be fundmentally incorrect and a step in precisely the wrong direction. As a general scientific problem, before increasing our refinements in one direction we should and must attempt to control some of the larger errors in another direction mentioned above. These errors are particularly concerned with the problem of the standardization of the individual.

7. All time-study men will agree that a fundamental preliminary step consists in a systematic standardization of equipment, methods and tools before any time studies are begun. Management engineers have made marvelous progress along these lines. I need not remind this group of the studies of Mr. Taylor and Mr. Barth on the art of cutting metals and the science of re-speeding machines. From reading Mr. Taylor's "Principles of Scientific Management" it is very clear that he appreciated the importance of standardizing the human beings who are to do the work, as well as the equipment. This phase of scientific management has, however, been almost totally neglected up to date. The reason seems to be that it has been nobody's job. Industrial physicians have been concerned with illness; industrial health has not yet been studied systematically. In fact, this work is in its earliest beginnings.

8. There are three general phases of human standardization: (1) physical standardization; (2) physiological standardization, and (3) psychological standardization. I wish to speak briefly about each of these three phases.

9. By a physical standardization of individuals we mean an inquiry into the total muscular strength required by a particular job. The method of measuring total muscular strength devised by Dr. E. G. Martin of Stanford University has already proved successful in industry. In a recent publication of the United States Public Health Service, Dr. Martin has shown that there is a definite correlation between total muscular strength and output. This correlation is not very high to be sure. It has a value of approximately —.50. However, statisticians consider such a value to be within the significant class. The practical value of physical standardization consists of establishing definite limits of strength required to do the particular work successfully. For example, if an individual has a total muscular strength of 3000 pounds on the Martin scale and the weakest individual who is successful at the job has a total strength of 2200 pounds the employment office would not consider engaging a man and placing him on this same job whose total strength did not come up to say 2000 pounds. Dr. Martin's method is extremely practical for it requires only some two minutes to make a single set of observations. Furthermore, the measurements are made with the individual completely clothed, which has obvious practical advantages. How far Martin's method may prove to be applicable in industry in the future I will not venture to predict. It is, however, important for management engineers to know that work is being done and has been done along the lines of physical standardization of industrial workers which has a great and important practical significance. Such standardization is obviously of use principally in jobs requiring a considerable expenditure of muscular effort.

10. The practicability of so-called physiological efficiency tests is less obvious. The physiological tests that have thus far been devised are principally concerned with the efficiency of the heart and circulatory system. You are familiar with the fact that after light exercise the heart rate increases. The time required for the heart to return to its normal rate is used as an index or measure of the heart's efficiency. This subject has been principally investigated in this country by Drs. C. Ward Crampton and Schneider of Wesleyan University. Dr. Schneider's test was used during the war in the selection of men who were especially fitted to become aviators. As in the case of the test for physical strengh the physiological efficiency test would be of greatest importance in jobs requiring much muscular effort. I have in mind women who work in sail lofts and dock workers who handle heavy loads at high speed. Other cases will occur to you.

11. Another group of investigations in which physiologists have been particularly interested has been concerned with the carbon dioxid output of the human machine during work. Without going into great detail in this fascinating subject I should like to call your attention to certain discrepancies or neglected points that occur in making out a so-called workingman's budget. According to the observations of Greenwood, Hudson and Tebb, the individual engaged in heavy labor must spend nearly five

per cent more of his income for food in order to maintain an efficient standard than the individual who is engaged in relatively light work. You are all aware of the fact, however, that the heavy laborer receives the smaller wage. So far as I know these facts are consistently neglected in all attempts to establish a minimum working-man's budget. In England attempts are being made by Dr. Waller to measure the calorie consumption of heavy workers. It will interest you also to know that we find corroboration of the familiar fact that the man on piece work shows a higher carbon dioxid output than the same man on a day wage. In other words, he does more work, he works faster on a piece-work basis than on a day basis.

12. The most complicated phase of the human standardization problem lies in the psychological field. The uncertainty of some portions of the technique makes it peculiarly open to fakirs and charlatans. There is, however, only one recognized method of procedure in psychological standardization in industry. We must select a group of workers of known performance and after a careful analysis of the job, test out any particular tests which we believe to be important on this group of human beings. When we find a test which is done with a high degree of proficiency by workers of known skill, we may reasonably assume that the test has a certain predictive value for use in the employment office. We must, however, pay particular attention to testing the test. Unless this is done the whole problem of psychological standardization is better left alone. We must calculate a coefficient of correlation between our test and the performance of our workers and this coefficient must lie above +.50 before we can accept it as being of practical use. A practical illustration from some experiments that Major Dunham and I have been carrying out with army rifle shoes may perhaps clarify this matter further.

13. We suspect that rifle-shooting ability might depend to a certain extent upon the control of so-called natural tremors in the hands and arms of individuals who were shooting. We tested this question out on a number of individuals by having them hold a small brass stylus in holes of varying size in a brass plate. When the needle came in contact with the wall of the hole an electrical contact registered the touch. It was a simple matter to count the number of contacts and note the size of the hole and in this way we established a basis for scoring the steadiness of different individuals. Through the co-operation of the officers of the Third Army Corps we were able to test out a large number of men at Camp Meade. We found that there was indeed a correlation between steadiness and rifle-shooting ability and that in general men who shot well likewise were very steady. The tendency for rifle-shooting ability and steadiness to fall together, that is the correlation between rifle shooting and steadiness, we found to have a value of about +.60. We have, therefore, tested the steadiness of men of known rifle-shooting ability. It remains for future workers to show whether men can be taught to shoot in the psychological laboratory by learning to control their natural tremors.

14. In the remaining time at my disposal I should like to call your attention to certain interesting phases of the so-called working capacity idea. We customarily plot human output on a base line which is supposed to represent the working capacity of a particular individual. A simple laboratory experiment, however, will convince you that this so-called working capacity is an extremely elusive and uncertain thing. In my laboratory in Baltimore I have an apparatus with which I can measure the amount of work done by a student, the work consisting of raising a weight with one finger. The apparatus which we call an ergograph has one serious defect, in that it does not really show when a man is completely tired. After I can no longer lift seven pounds I find that when I take one pound off I can still raise six pounds for a considerable period. In the case of certain unsuspecting individuals we have found that when they are told that a pound is about to be removed but a pound is actually added, their work continues nevertheless precisely as though a pound had been removed. In other words, such individuals imagine the load to be lighter and consequently work successfully. An even more striking illustration of the power of suggestion is shown by the experiments of the late Doctor Nicholson which were recently published in the Johns Hopkins Hospital Bulletin. Doctor Nicholson placed his subject in an apparatus similar to my own and hypnotized him when he could no longer work. The suggestion of work made the subject continue lifting the weight quite as if he had never been fatigued. I do not wish to be understood as advocating general hypnosis for industrial workers in order to increase production! There is, however, a certain fundamental psychological significance which you will all recognize in these

somewhat crude illustrations. Men and women will work if they feel like working, and if they do not feel like working they simply sabotage whether consciously or unconsciously. The most complicated time-study technique and the finest rate setting in the world will not make human beings work unless they co-operate. The removal of the normal inhibition which keeps human beings from giving their best in industry, in other words, the release of the will to work represents, it seems to me, the most hopeful, untouched field in the whole production problem. The man who can release the complete co-operation of his employees will get production. Mutual suspicion between management and men, however, can never lead to anything but complications. Just how far the attitude of suspicion and mistrust and social unrest is dependent upon certain broad health and happiness factors is shown clearly to my mind by figures recently published by Dr. E. J. Collis. (Table I). These figures show that in the British coal fields there is a general correlation between the number of coal miners who voted for a strike in August 1920 and the morbidity and mortality rate in the different coal fields. Nottingham had the smallest strike vote and the lowest accident and death rate, whereas Lancashire had the highest vote and the highest death rate.

TABLE I

The Relation between Mortality and Industrial Unrest in Certain English Coalfields.

Coalfields	Deaths from all causes. (1910-12)	Precentage of Miners Favoring Strike. (August, 1920)
(Yorkshire)	(758)	(51) A
Nottingham	570	55
Derbyshire	591	71.9 B
Durham and Northumberland	635	77.9
South Wales	777 C	77.9
Lancashire	941	89.7

A—A strike, affecting this coalfield alone, took place in August, 1919; and the effect of the rest then taken is generally supposed to have influenced the voting.

B—Includes South Derbyshire.

C—Includes Monmouthshire.

The above figures were compiled from Collis and Greenwood, The Health of the Industrial Worker, pp. 75-76.

15. I hope I have made it clear to you that the management engineer must look for a new ally in the physiologist. In my opinion time study will be improved by greater attention to the standardization of the human machine rather than by a further refinement of the technique of time measurement. It is sounder scientific procedure to get after the big errors first. At present these large errors lie along the lines of human standardization and not in the method of time measurement.

VIII. CLOSURE

By Frank B. Gilbreth and L. M. Gilbreth

1. It is not surprising that some management men who have commented unfavorably on our "Indictment of Stop Watch Time Study" should have defended the old practice, because

a. It is associated with the old days of struggle and victory over the "rule of thumb" manager;

b. Dr. Taylor himself used it and advocated its use;

c. They are, many of them, adept in its use compared with beginners, and thus feel that they already have the advantage of years of experience over others in the practice of management;

d. It is their livelihood.

e. A few of them are directly interested in profits from the sale of stop watches, time study devices or books describing stop watch time study methods.

f. They are apprehensive that if the validity of stop-watch time study data is assailed, the tasks and rates based on them are threatened also.

2. As many of these discussions are by men justly prominent in the field of management, they merit the most careful consideration. We shall, therefore, discuss them paragraph by paragraph, reviewing their meaning and answering the criticism in detail.

REPLY TO MR. BARTH

3. We consider first Mr. Barth's "A Defense of Time Study," as he calls it.

4. Mr. Barth is perfectly justified in strengthening his qualifications as a discussor of our paper by calling himself a "direct disciple" of Dr. Taylor, in paragraph 1. It is perhaps permissable to state, if Dr. Taylor's approval is to be used as a standard of measurement of qualifications and the right to define terms officially for the Taylor System, that on the three most important occasions[1] presented for dis-

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[1] 1. Meeting on "The New Conceptions of Business and Industrial Efficiency" held under the auspices of "The Civic Forum," Carnegie Hall, April 28, 1911.

2. Answering the questions that were sent to the "American Magazine" for further information on Scientific Management after Dr. Taylor's articles in the March, April and May, 1911, issues. The answers appear in "Primer of Scientific Management," 1912.

3. Western Economic Society's Conference on Scientific Management, March 14, 1913.

cussion of the questions of Scientific Management, and on several other important occasions, Dr. Taylor selected us as his personal representative to handle for him and in his interests his side of the argument, and to explain and answer oral, written and printed questions, without special conference with him at the time.

5. A further indication of Dr. Taylor's approval of our fitness to make decisions in management was his asking us to join him in writing a book on our subject of motion study, which he had never recognized or considered, combined with his subject of time study, which we had never recognized or considered. This exceptional honor, which we have always fully appreciated, we were obliged most reluctantly to decline.

6. In paragraph 1 Mr. Barth has put on record what we have always contended, what Dr. Taylor said, until he changed his views in 1912, and exactly what his "direct disciples" have always believed and practiced, not only before 1912 but also ever since, that "the object of time studies is to determine a fair time to allow a worker for the performance of a task"; or to determine "how long it takes to do work," as set down by Dr. Taylor in "Shop Management." Dr. Taylor changed his viewpoint, as is recorded in his discussion of paper 1378 read before the American Society of Mechanical Engineers in 1912, which we shall discuss at length in our forthcoming "Management Commentaries," but his "direct disciples" still hold to his original views.

7. We have always maintained, and the discussion herein now confirms our contention, that the "direct disciples" have no conception whatever of motion study, other than something that "is the same as time study." Time study does not record elements of skill. *This one thing is sufficient in itself to distinguish the two for all time.*

8. Mr. Barth, now, in 1921, with the statement undisputed by the Philadelphia Section of the Taylor Society, and *"fair time to allow,"* underlined by him, has recorded for all time without ambiguity and beyond recall, that "Time Study is for Rate Setting." That is the exact title of Mr. Merrick's book. There is no question, therefore, that the statements in our paper are justified.

9. It is interesting to note, in paragraph 2, the stress on individual differences. This is indicative of a fundamental change of thought in the entire world in the last ten years. It seems doubtful if he is cognizant of its implications. In this paragraph Mr. Barth states that the fact that no two workers accomplish their work in the same time, is sufficient reason for accepting inaccurate time study made by the non-condition-recording stop watch. Can it be possible that he still does not recognize the great advantages of the micromotion method, which not only does all that the stop watch does, and this without error, but records all the surrounding conditions, which also may show the very *cause* of the lack of regularity? Can he not recognize that times are different, usually, because methods are different? Can he not recognize that without the conditions being recorded the best portions of methods cannot be selected for the One Best Way? Can he not realize that quality of method and speed at the time are always confused, with stop watch times? Can it be possible that he still fails to recognize that *perfect accuracy* of minute times is *not the direct product* or the chief aim of the micromotion method, but is a *free by-product* of the record of the motions, that defines absolutely and in detail the method on which the "fair contract" is based? We are not losing sight of the great benefits resulting from the "task" or "program" or "time-table," but they should be, and for best results must be based upon the clearly identified subject matter of a fair contract based upon recognizable facts.

9a. With the micromotion method, the contract *is* fair and the minds of the contracting parties *have* met, because the method to be used is identified on the film. With the stop watch method if a "fair contract" means merely an agreement between the employer and employees that the employer will pay the employee the high rate if he makes the number that is called for in the task of a quality that suits the varying whims of the management, then there is also a contract.

9b. Many "tasks" or "fair contracts" are not fair because the method which is supposed to be clearly identified in the instruction card "is not identified at all so far as the motions to be taught and to be used are concerned." For example, the "instruction cards" as shown in Mr. Merrick's book "Time Study for Rate Setting" do not identify the motions at all. If the "fair contract" is not based upon a definite method and sequence to be used to obtain the task time, the minds of the parties have *not* met. Furthermore, unless the tolerances and inspection are clearly circumscribed, the minds of the employer and employee have not met and there is no real agreement or fair contract.[1]

10. The two reasons summed up in paragraph 3 for establishing a "degree of accuracy," "in reaching a satisfactory time allowance for a task," i.e., variation between workers and unevenness of the individual worker, neither excuse stop-watch time study for its inability to time the activity accurately, nor belittle the usage of the micromotion method in recording all such differences in errorless unmistakable detail, along with the likenesses, as fundamental data for determining the One Best Way. Here again Mr. Barth *emphasizes his one thought,* namely, *time study* for *tasks.* There is no thought or mention of observations for the worker in his learning period; no thought of recording comparative data as to merit of method; no thought of exposing the best that has been done to the learner; no thought of having a detailed ideal of method to come to; no thought of tapping the infinite experience of the workers of the present and all succeeding generations of workers' cumulative progress in method. No! Only "time allowance for tasks," and "fair time to allow a worker for the performance of a task" and "task within the time allowed," and "if he falls short of performing the full task within the time allowed."

11. The task does excite the workers' ambition and desire to do the work "in the time allowed." The task does not educate him in the best method that has been done, as a base line, upwards from which he may use his inventive ability and experience for advancement. Our paper is not merely about tasks. There is an endless amount of work possible before and after the quantity of the task is established that is of the greatest importance, even if tasks are never set. Yet Mr. Barth ignores, with the apparent approval of the Taylor Co-operators, the principal feature of our indictment of stop-watch time study. Is it because they refuse to see the educational feature and the importance of recording in detail the One Best Way to do work,—or do they prefer to confuse the issue by discussing only the much less important feature of "Time Study for Rate Setting?"

12. In paragraph 4, it is no more fair for Mr. Barth to infer that we condemn stop-watch time study "merely" because we have invented "a far more accurate time measuring device," than it would be for us to say that he defends the stop watch because he has co-operated on a book on stop-watch time study and has put himself on record for all time as endorsing such inaccurate methods. As a matter of fact, the invention of the micromotion method did not come for several years after our condemnation to Dr. Taylor of his stop-watch time study method, and our promise made to him in 1907 that we would design a time study device that would do away with all the faults, inaccuracies and mistakes of stop-watch timing.

13. Note that Mr. Barth now completely concedes the superior accuracy of the *devices* of our method.

14. In paragraph 5 the fact is emphasized that the industrial engineer often has to be satisfied with second best. In what way does this prove that he must or should be satisfied with the inaccurate, non-recording, rule-of-thumb stop watch? Equipment is stressed, therefore, evidently because the newer devices are thought to be too costly, or too difficult to secure, operate or install. We have answered all these objections in our original paper.

15. From paragraph 6, it is evident that the micromotion method is objected to as being too costly. The comparison of the stop-watch time study man to the astronomer and biologist is very flattering,—to micromotion advocates as well as stop-watch men. It certainly implies that only lack of funds prevents the latter from acquiring the more accurate apparatus, for surely no astronomer would remain without a telescope, no biologist without a microscope, if such could be secured, because the micromotion method will pay for its entire cost almost from the beginning of its use. But this is not really a parallel case. It is true that a scientist is a scientist even though he has ***no*** apparatus, but we maintain that no scientist would *advocate* using unnecessarily inaccurate methods and devices when accurate are available. It is not the question of his ***possessions*** but of his ***attitude*** that we are discussing. Does Mr. Barth wish to convey the idea that a time-study man "because of his own poverty, or that of the institution with which he may be connected, is unable at once to secure the very latest and best equipment for his research work," is warranted in going to some of our great colleges and universities and misleading students and their teachers

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[1] "'The minds of the parties to a contract must meet as to all of its terms.

Lord vs. U. S. 217 U. S. 340.

Fire Ins. Association v. Wickham, 141 U. S. 564.

Minneapolis etc. R. R. v. Columbus Rolling Mill, 119 U. S. 149.

Eliason v. Henshaw 4 Wheaton, 225.

Wheeler v. New Brunswick etc. R. R. 115 U. S. 29.

If any portion of the proposed terms is not settled, or no mode is agreed on by which it may be settled, there is no agreement.

Barrow S. S. Co. v. Mexican Cent. R. R. Co. 134 N. Y. 15."

by deliberately and intentionally advocating the inaccurate stop-watch method of time study, or misinforming the profession as to the best methods of time study, as has been done with his unqualified approval in the book "Time Study for Rate Setting"? Can Mr. Barth cite the possible poverty of an institution as sufficient reason for his first public expression of any praise whatever of the micromotion study plan, coming after our indictment of the rule-of-thumb stop-watch method?

16. The situation in the colleges is serious. Some in this country have already adopted micromotion study, and the securing of accurate times as a by-product of method records. Others, under the influence of stop-watch time study men, and taught by professors, who, realizing their lack of training in Scientific Management, have intrusted the subject of timing to "time study experts," have little knowledge, no knowledge, or misinformation as to micromotion study. A third group have been taught "that the stop watch method and the micromotion method are alternatives" and never find out till they have learned wrong habits of taking times and lived thru the heart-breaking experience of finding their carefully accumulated data worthless, that they have been devoting themselves to acquiring what is fast, and deservedly, coming to be a "lost" art, instead of a science, founded on a rapidly accumulating body of facts.

17. Our indictments of stop-watch time study, psychological and statistical, have been made primarily to inform the young men on the subject,—and the educational indictment to follow in forthcoming books will be developed along these lines.

18. We agree absolutely with paragraph 7. By "means" Mr. Barth evidently means devices. Having conceded the superiority of our devices he turns to a defense of stop-watch time study methods. We wish to state only that Mr. Barth, in his own attempts to make the findings of the stop-watch more accurate by applying his own knowledge of mathematics has shown the untiring devotion of the true scientist. It seems a pity that he has been handicapped so many years by the fact that the inaccuracy of the data he has had to work with has made his task such an ungrateful one. For example, such minute times as are derived by the algebraic equations in "Stop Management," American Society of Mechanical Engineers' edition, paragraph 377-378, Harper edition, pages 172-173, have been recorded in greatest detail as to method and with errorless times by a small boy with three or four revolutions of the handle of the camera.

19. In paragraph 8, Mr. Barth rightly says that our apparatus "cannot automatically pick out the most suitable in a group of workers to which to apply it." We have never claimed any such human intelligence for our devices. It can, however, be said to their credit that neither do these inanimate apparatus warn their users, as does Mr. Barth in Mr. Merrick's book, page IX, not to seek to record the "extraordinarily expert operator."

20. Mr. Barth has never had the experience, and could not with the stop watch, obtain and study new information pertaining to skill study usable for making the workers more productive, increasing their earning powers, and adding to their comfort, that the micromotion method acquires. He therefore criticises it as he does in the concluding part of the paragraph, as follows: "I cannot see that it can do much more for us than to measure more accurately the elementary operations performed by the particular worker photographed."

21. Believing, as he does, that the prime aim of studying the activity is to determine "a fair time," (Barth paragraph 1), and apparently thinking that the micromotion method has for its aim simply getting more accurate times, he naturally fails to appreciate that it bases its superiority on its ability to furnish data for skill study, the obtaining of the One Best Way to do work, and the education of the worker, and regards the times simply as a valuable by-product of its real work, which is the *recording of methods.*

22. In our books "Primer of Scientific Management," page 56, "Psychology of Management," chapter 8, and "Motion Study," page 36, we called attention to the great possibilities resulting from the transference of skill, and, while the majority Committee of the American Society of Mechanical Engineers recognized this principle and made it the subject of their epoch making paper 1378 at the December meeting, 1912, the discussors of our paper in 1921 completely fail to grasp the possibilities of finding and recording the details of the One Best Way and transferring the skill of the most expert to all the others.

23. Mr. John G. Aldrich, an expert on engineering and management, wrote in 1912, "Micromotion Study furnishes a means for the transference of skill from man to machine. More important than this it furnishes a means for the transference of experience from a man who has had it to one who has never had it."

24. In paragraph 9 Mr. Barth apparently has and gives an entirely wrong impression of our work. We

have today for his inspection over nine thousand written standards and standing orders pertaining to management, some of which date back to 1897, two years before Mr. Barth had ever worked for Dr. Taylor. Our work consisted for twenty-six years of handling thousands of men on our own payroll, from Eastport, Maine, to the Pacific, and from Montreal to the Gulf of Mexico. Prior to this we had seven years experience as superintendent and head superintendent in responsible charge of large work, with a grand total of thirty-six years studying and practicing management.

25. The experience has been supplemented by complete installations of Scientific Management. In many instances the work of making micromotion study has been but a small part of this. However, it is true that it is the basis upon which we have founded our standards and standing orders for the installation of management, which have been applied not only to "repetitive work implying exceedingly minute motions," such as textile and cloth handling industries, scientific instrument industries, and all branches of office work, but also to such machine shop work as has to do with automobiles, battleship crank shafts and screw shafts, and many kinds of industries in between. We grant that the micromotion method has been highly successful also on repetitive work that the stop watch demonstrated itself utterly unable to better or cope with, though handled by its most highly trained advocates and users.

26. Mr. John G. Aldrich, President of the New England Butt Company, speaking of the micromotion method and process, stated in 1912[1] "previous times have been reduced over two-thirds." This work can now in his factory be seen being done, today, nine years after, in the same way as we laid it out in 1912, the reason for no change being that it was done near enough to the One Best Way in 1912 to warrant letting it alone ever since.

27. Paragraph 10 is evidence of the weight that Mr. Barth gives to the profit that comes from the study of the machine, as compared with the human element,—not as disparaging the latter, but as an expert in improving the former.

28. We are glad to have this opportunity again to express our appreciation of the fine work of Mr. Barth in respeeding and rebuilding machines, as outlined in paragraph 11. In our installations we do not attempt to handle these thru micromotion study alone, as we have also, of course, available the other methods of betterment of scientific management, yet even in this field we have seen many a machine completely rebuilt as a result of the examination of the micromotion films. As to tool rooms, which he cites, we have seen none that compared in efficiency with those that have been installed with knowledge of and due regard to the underlying laws of motion study that have been derived from an intensive study of micromotion data. The laws of tool handling, moving, storage, repair and tool maintenance, developed in the course of our years of micromotion studying the complete Taylor system, warrant any large organization whose tool rooms have been done without such micromotion experience and view point having them done over again.

29. In one instance a "direct disciple" after long effort succeeded in getting one of our clients to let him try to improve a tool room that had all the Taylor merits and practice plus the refinements that come from such micromotion method of analysis. At the end of a few months his services were dispensed with and those things which he did not understand and therefore changed, were put back to the condition left by the micromotion method. Many similar instances can be quoted where accurate measurement cannot be improved upon by mere knowledge of tradition, without the knowledge of the theory.

30. In paragraph 11 Mr. Barth advocates "past general experience and the common sense that goes with it." He ought to know that these do not forsake the user of the micromotion method, tho their use alone savors of the "rule-of-thumb" that Dr. Taylor so strenuously tried to supersede. The micromotion method gives one a *measured experience,* and common sense backed up by measured proof, that correct and supplement the findings of general observations.

31. In paragraph 12, Mr. Barth again overestimates the emphasis placed by the micromotion method on its ability to get *more accurate* "times" for *rate setting purposes* than does the stop watch. We claim that it costs us nothing to get "absolutely accurate times" since these occur on our records simultaneously with the *record of methods,* the value of the latter paying for *all* the data, even that taken on work that has been already stop-watch time studied. But we also say that no time data, no matter how accurate, can compare in value with motion data.

32. There is no doubt, as Mr. Barth says in paragraph 13, that electrification does add a variable to the study of machines, but this was to be expected and is

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[1] See Transactions of the A.S.M.E.—Page 1184.

being successfully handled, and in no wise furnishes an excuse for not obtaining the most adequate and descriptive data of what occurs, in fact it rather furnishes a new reason for accumulating such data.

32a. In paragraph 14, the alleged inability of the micromotion film to record certain important data is criticised. To this we reply that anything that cannot be recorded, in situ, by our motion picture machine to our complete satisfaction is written on slates, which are always provided for that special purpose, and then photographed in the films. In this way much more information can be and is recorded than Mr. Barth lists as essential. It may be interesting to note that if there is any question concerning the particular film that Mr. Barth refers to, it is possible to re-examine it at any time, to decide the matter, without prejudice, for what is once recorded is not dependent upon anyone's ideas as to what occurred and its value is in no way associated with the psychological variables of memory, prejudice, bias, enthusiasm and personal interest, that have so often made stop-watch time study data worthless. The fact that Mr. Barth, as he says, sees no value to the film except the accurate minute times simply shows that he fails to comprehend and appreciate the importance of the capture of the skill of the super-expert and its transfer, the educative value of finding and teaching The One Best Way to do work, and the value in building up an organization of first-class workers, so trained.

33. It was not the "direct disciples" who recognized the benefits of accurate measurement. It was one of our clients who wrote:

"The micromotion study enables us:

a. To capture the experience of the most skilled workman and record it for the benefit of all;

b. To determine the motions of least waste;

c. To teach the best known method only;

d. To analyze, measure and compare new data so that improved methods may be constantly standardized as fast as discovered.

"I believe that the time will soon come when we will have a national bureau of standards of best methods, and micromotion study will provide a means that the government can use for collecting and recording the best practice of the workmen in our industries."

34. We appreciate the attitude of Mr. Barth in paragraph 15, and can testify that he has always been outspoken with praise or blame.

35. In paragraph 16, Mr. Barth says "it did not take me long to learn to make allowances for Dr. Taylor's emphatic statement, as to the importance of the scientific study of unit times." He also speaks of Dr. Taylor's emphasis slightingly when he says that Dr. Taylor "spoke as the enthusiastic originator and reformer seeking a following."

36. We disagree with Mr. Barth, and we agree with Dr. Taylor's statement, exactly as he makes it. Dr. Taylor exhibits here, as in many other cases, an *instinct* for the correct system, even tho he did not possess the correct apparatus or understand the only method which conforms to the descriptions of his philosophy. It is because of this and other instances where the true Taylor philosophy has suffered in the hands of Mr. Barth and of many other loyal friends of Dr. Taylor, that we have written for the benefit of the young engineers a series of Management Commentaries which will be issued in the immediate future.

37. Mr. Barth stresses the point that the same operation done twice may vary in time much more than the difference between two time observations of the stop-watch timing method. Of course it will, but if the method is also recorded and all the individual therbligs are timed, it is then possible to study the unit times with due reference to the method employed and the detailed result. This is what Dr. Taylor meant. If one does not get this point, then he misses that philosophy upon which, as Dr. Taylor said, "this whole system rests." Mr. Barth says that he does not take Dr. Taylor's statement about this "seriously," in spite of the fact that Dr. Taylor emphasizes this in detail in many places in his writings, several years apart. Of course it is not to be expected, then, that he will take the micromotion method seriously.

38. Mr. Barth's belief that in his own case the preparatory work has been of more value than the time studies, is doubtless justified, but such preliminary work can attain its maximum value only when it is based upon the experience of previous accurate motion studies and time studies. We have between nine and ten thousand such standards so derived, complete and ready for selection and immediate installation, unable before "subsequent time studies" are taken. These are based upon long accurate motion study and "the study of accurate times," and they bear out Dr. Taylor's statement to the letter, which Mr. Barth says he does not "take seriously."

39. In paragraphs 18 and 19, Mr. Barth defends Mr. Merrick's unscientific statistical methods. We have only to state that they are opposed by the entire statistical profession. We do not see how Mr.

Barth, the expert mathematician, can condone such procedure, when more precise methods and devices are available today.

40. In paragraphs 20-22, the comparison to a telescope and microscope is meant to be complimentary, but the feature of *permanence* of record which is so important in micromotion study is neglected. The "guess work" advocated simply shows how different one's views of one's own field and that of others are, for Mr. Barth scorns guess work in respeeding of machines. In Mr. Barth's comparison with the telescope, which we think quite irrelevant, we would call to his attention that even here the best work was not done until the astronomer used photography.

41. In paragraph 23 Mr. Barth chides us for calling attention to the secret time study of the stop-watch advocates. We persist in saying that the stop-watch is still used today in many places in the manner he disclaims. It is to the credit of the Philadelphia Section of the Taylor Society that they passed, after hearing his objection, a resolution against secret time study after our paper was discussed. The reason that stop-watch time study men are prone to use secret time study is because they do not know when the observed man is working at the proper pace, and have no way of knowing, whether or not he really is expert. They have no method for judging exhibition and demonstration speed, as compared with economic speed, because they have no fundamental correct data or norms with which to compare his records. Neither have they their records in such form that they could compare them, if they did possess such norms. Therefore, the secret time study men are continually prone to resort to "peeking thru a knothole," as it has sometimes been truthfully described with facetious intent, and to class such secret observations under "production studies," with the idea of making them more justifiable. For Mr. Barth to say that secret time study "has not been done since I became associated with Mr. Tayor," must be construed as meaning that it has not been done by him, or that he has not been in close touch with stop-watch time study practice.

42. In paragraph 24 Mr. Barth has opened a large subject when he states that the micromotion method does not necessarily imply "the consent and full co-operation of the worker." We must repeat that we always observe *the best man obtainable only*, which gives us an entirely different procedure and result from Mr. Barth's practice of not observing the "extraordinarily expert worker," which he specially warns against. The worker who does not thoroly cooperate is, therefore, of no use to us. Micromotion records are so perfect that we can instantly detect him by his variation from established norms, should we, by mistake, record a man who is not cooperating fully. This fact stands out clearly in the Simultaneous Motion Cycle Chart, which we make from the film. Regardless of what he may desire, the worker who does not cooperate cannot hide that fact from us. Obviously, the observer might photograph a worker who did not consent and who did not desire to cooperate, but neither one would be a party to it, if he could help it, for the record, when completed, would be worthless from the standpoint of finding the One Best Way to do work.

43. In the final three paragraphs of his discussion Mr. Barth criticises us for believing that efficient planning is based only on standards derived from accurate data. Apparently he fears that superstandardization will lead to rigidity. As a matter of fact, it leads to the standardization of such minute elements that we have a flexible equipment to meet the emergency, which is always expected and prepared for. It is axiomatic that the more accurate the data on which the planning is based the easier it is to keep to schedule. It is a law of statistics that the accuracy of a whole is no greater than the accuracy of its components. For further proof of the correctness of the theory we have the experience of our practice. We may say that even the blank forms used in planning and control, and the old methods of their making and their use, have invariably been found inefficient and out of date, as a result of recording and analysing the old methods accepted by management engineers, without question, before our micromotion studies of them.

44. Mr. Barth has not discussed the relative values of the two methods for purposes of teaching. He has acknowledged the superiority of our devices from the accuracy standpoint. His criticism of our methods is from the cost standpoint only, and here he has been shown to be mistaken. It need only be said here that the micromotion method does not always imply the use of film for recording immaterial happenings. The camera has two shafts for the handles, one of which takes only one picture per revolution, and such a picture can be taken as often or as seldom as desired. Besides, the multifilm pro-

vides for taking such a large number of pictures on a foot of film that the cost is negligible. Its greatest immediate merit is that it pays in actual savings. Most important of all, even to those who misunderstand, ignore or oppose it, the work has come to stand for precision, for fairness and for permanence.

REPLY TO MR. MERRICK

45. The discussion of our friend Mr. Merrick shows his usual fair spirit. In his second paragraph he sums up briefly and accurately our claims for the micromotion method, and the relative importance of motion and time records.

46. In paragraphs 3 and 4, he gives the real reason why both he and Mr. Barth underestimate the importance of the newer methods and believe the stop-watch gets results on "time data" that are "close enough." If "time data" is all that is wanted, a stop-watch probably is close enough. It certainly is close enough for those who are interested in the work only temporarily. Because Mr. Merrick and Mr. Barth have had occasion to study machine time perhaps oftener than they have handling time is not sufficient reason for their not having accurate observations showing *all* conditions, as often as they would snap a stop-watch. In answer to his argument, it is to be said that where it is desired to take observations at long intervals, such as where the handling time is but a small per cent of the total time, only enough pictures need be taken during machine time to record the conditions as they actually are, slates being photographed along with the operation, as we have already explained.

47. It must be remembered that those who know about the possibilities of savings by motion study and also those who want permanent data regarding the surrounding conditions are not looking for mere handling time data and machine time data only. Therefore, even on the rare and unusual jobs to be found only on the heaviest machine work,—and our organization has been and is working with "repeat order" satisfaction on that kind also,—there is no commercial or scientific argument for not getting better and more permanent records.

48. During the handling time the full possibilities of the micromotion method are available and ready instantly to record the combinations of motions used and the method in detail. There seems to be no excuse for substituting the stop watch on a hypothetical ninety-five per cent of the observation, as the micromotion equipment is acknowledged superior even on the hypothetical five per cent, and can furnish a continuous or intermittent, homogeneous, permanent record of the entire work process. We have jobs running today such as Mr. Merrick describes, and can furnish indisputable correct time and motion records, such as never have been and never can be furnished on any work that has been studied by the stop watch only.

49. The amount of percentage of the handling time to that of the task is irrelevant to this discussion, in any case. The argument here is on the accuracy of times, *together with indisputable records of attending conditions* at the time that the times were taken, and on the relative cost of the two methods of obtaining these. The micromotion method has been proved, in the original paper, unsurpassed in these respects, as mentioned.

50. In paragraphs 5 and 6, Mr. Merrick outlines and concedes the need for the micromotion method on highly repetitive hand work. It is true, as he states, that recording times on such work with the stop watch requires "intense application." It is to be added that such application does not insure accuracy of times and it precludes the possibility of also recording conditions, thus no method study or skill study can possibly run concurrently. The reason that stop-watch time study men have done so little Fatigue Study, comparatively, is because they have no complete records of the fatigue-causing factors which they can study leisurely. The micromotion method records rapidly performed small cycles with the same ease that it records slow work, and, after the apparatus has been set up, the observer is free and ready without distraction to study or coach the worker under observation. As we said in 1915 in a paper "Motion Study and Time Study Instruments of Precision,"[1] "No specially gifted observer, combined with the most willing and efficient recorder, can compete with it for observing and recording facts."

51. It should be remembered that more than ten million American workers have life work that consists principally of a comparatively small number of cycles of less than ten seconds each. Practically all of the skill-requiring motions of the textile trades consist of a very few cycles of less than five seconds each. In such cases, the ordinary speed of the motion picture camera is entirely inadequate

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[1] "Applied Motion Study"—Chapter IV.

to record with sufficient speed the skill of the super-expert. In some such cases, we have been obliged to devise special cameras that operate as high as 115 pictures a second and then for a second time, an entirely new motion world was opened to us. A moment's consideration of any unbiased critic will result in admitting that any record of say, five to ten cycles, less than ten seconds long, that represent a life work of craft skill achieved, is warranted.

52. Moreover, we have found that micromotion and cyclegraph records may be made of mental as well as physical work,[1] which makes them essential to recording the work of a far larger per cent of workers.

53. Mr. Merrick has made no mention of, or excuse for, the reams of time study data which he has made and has not used in his book. He has made no attempt to answer our indictment sentence by sentence, paragraph by paragraph, or subject by subject.

54. We have indicated stop watch time study in general, and his methods, as representing the best of that inaccurate practice, in particular. Mr. Merrick replies to our indictment by saying he is "thoroly convinced that for ordinary practical purposes the stop watch will continue to be the most convenient time measuring device."

55. If *convenience of device* is all that one demands of records of workers, then it is perhaps quite natural to feel satisfied with inaccurate equipment, and inaccurate temporary results.

56. We have invited Mr. Merrick many times to visit us and to become familiar with our methods, and he has not as yet availed himself of the opportunity. We have enjoyed an uninterrupted friendship with him for fourteen years, have advised him as to cameras,—which he did not buy,—sent him a copy of our latest book, and indicted his methods in this paper, and we do not know what more we can do for him.

REPLY TO MR. KENT

57. Mr. Kent was, as he states in paragraph 1, the first person outside of our own family, organization and patent attorney, to be told about the micromotion process. He worked with it with us after the devices were perfected, and was, we believe, the first to appreciate the benefits of the process. He wrote, in 1912,[2] "Micromotion study is the most powerful tool ever offered the engineer to measure the efficiency of the worker." "Time study is the basis of all modern management. The provision of a machine to make time study should be as revolutionary in the art of time study as was the invention of the power loom in the art of weaving. Among other things, it absolutely eliminates the human equation. It provides a method in which there is not only no possibility of error in measurement, but which furnishes at once a true statement of the time elapsed in the performance of any operation and a record and instruction card of the best method of doing a job." And again, "Micro-motion study revealed the deficiencies of previous methods and permitted the development of the final accepted methods in a small fraction of the time and expense which would have been necessary under conditions existing before its invention."

58. Now let us analyze what he now says after nine years reflection. He states that he has "had no litle part in the preparation of Mr. Merrick's book[3]," and is "in a position to speak with some measure of authority upon both phases of the subject." In paragraph 2, he states that he has been an "ardent advocate of Mr. Gilbreth's methods of time and motion study for certain classes of work." The entire paragraph suits us to the letter, and it ends with the phrase "in a class by itself." Still he limits his advocacy by the phrase "for certain classes of work." We see in the two remaining paragraphs what classes he refers to,—namely, certain classes of *time study*.

59. Mr. Kent knows that our time study and motion study data can be used when they are "cold" just as efficiently as when they are new. We would suggest that he compare them in this respect with any stop watch time study data.

60. We would like to have him describe the various conferences where the accumulated stop-watch time study data which was collected by Dr. Taylor's "direct disciples" was reviewed by Dr. Taylor and Mr. Kent and others in 1914 and 1915, with the object of including it in a book on time study which later became Mr. Merrick's book "Time Study for Rate Setting." We should like to have him explain why voluminous time study data, such as that of the Link Belt Company and the

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[1] "Motion Study For the Handicapped," Pages 93, 94. Pages 7 and 8.

[2] Transactions of the A.S.M.E. Pages 1187-1189.

[3] See "Time Study for Rate Setting." Page XIV.

Tabor Manufacturing Company, is so scantily represented—in fact is conspicuous by its absence—in this book. This is not for our benefit, for we already know in detail exactly what happened and why, but we believe that if he will state fully just why it was necessary to do much time study all over again, it will be a worthy contribution to the subject of time study, a most pertinent addendum to this paper, and a most valuable document for the young engineers entering our profession.

61. Mr. Kent will probably answer that it is neither his duty nor his place to tell this, but we feel that it is only just to micromotion study that such a fair, friendly, well informed judge as is Mr. Kent should thus open the way for impartial critics to compare and evaluate the two types of data from the standpoint of recording the surrounding conditions and the possibilities of using such data from the standpoint of permanence.

62. We will state that we have never had reason to change our original methods of recording all the surrounding conditions in the greatest detail that attend any time-study and motion-study observations, as practiced in the beginning of our motion picture experience, when Mr. Kent had his most intimate knowledge of our work. Not one micromotion study that ever has been taken is any less clear, complete and understandable today than it was in the days when it was first developed. Furthermore, these studies permit re-grouping the subdivisions of the operation in any desired manner or sequence, and give results that are fully as efficient as new studies for recording the phenomena of behavior.

63. In paragraph 3, Mr. Kent says "There is time study and time study." Now let us remember the accepted time honored definitions of time study, namely, "time study is for rate setting;"—"Time study is the art of determining how much work a man can do in a day;"—and the confirmations of these definitions in the first paragraph of Mr. Barth's discussion. We will now again call attention to the fact that the purpose of micromotion study is finding the One Best Way to do work; and that the errorless time observations are a free by-product; therefore, the balance of Mr. Kent's discussion,—all that is contained in his paragraphs 3 and 4,—must be read with the full appreciation that he is here talking only of accuracy of times, without mentioning the features of motion study and transference of skill, which he compliments so highly in his paragraphs numbers 1 and 2.

64. He is perhaps unaware of the fact that we now have various sized cameras, some of which are very small, and that we can take as few records as are desired. Some photograph on film, others on plates, and for those who desire lowest cost, we can now photograph a negative or positive direct upon the paper. Surely, in the light of his experience with voluminous quantities of stop-watch time study records, where the surrounding conditions were not recorded, and were found unusable when old, Mr. Kent is not serious in even suggesting not taking a snap shot with the micromotion apparatus as often as he would press a stop watch. Perhaps he will still say that he does not know how to develop the pictures after he snaps them. If this is the case, we will agree, as a matter of long friendship, to have our organization in our laboratory develop them at cost or, as a matter of business, we will furnish him the entire apparatus for taking, film and developing and printing complete, to make time studies, for what it costs him to do it with a stop watch.

65. As for paragraph 4, we accept what Mr. Kent says about the two-foot rule and the piece of wood, but his comparison is irrelevant because for cutting only one piece of wood, under the conditions which he describes, there would be no need to record the surrounding conditions. Furthermore, because one has a machinist's scale is no reason for cutting a piece of wood to the sixty-fourth of an inch, when the tolerance is plus or minus a quarter of an inch. He has met our views exactly, however, in his last sentence. By all means let us use "the tool best suited for the job in hand." Therefore, for temporary and guess work, where it is desired to have no data of tools used or motions, or any record of surrounding condition, we recommend the stop watch. For work where accuracy and permanence of complete records are essential, we recommend the micromotion method, it being always remembered also that we recommend taking micromotion records *of the best man obtainable only*. The skill of the super-expert is too valuable, for further use in the present and the future, to be missed. We thus secure by-products of the records, that alone more than pay for the price of the entire micromotion procedure.

REPLY TO MR. COOKE

66. Mr. Cooke labels his discussion of our Indictment "Make Time Study Open and Above Board," but he is not fully consistent. He lays stress upon Dr. Taylor's "Being absolutely opposed to secrecy in time study when the results of such study were to affect in any way the wages to be paid to the individual on whom the observations were to be made," but does not state that it is not ethical to take secret time study on any man, whether it will affect his wages or the wages of his colleagues or not. Whether it is ethical or not, the workers consider it unethical, and even the advocates of secret time study admit that it hinders hearty co-operation "when the workers find it out."

67. We know of no case where taking secret time studies is justified, whether or not it affects the group of men on which it is taken, and what is more, such time study data are quite valueless from any standpoint.

68. We are glad that Mr. Cooke agrees with us that there is no excuse whatever for secret time study under any circumstances. We are opposed to it on principle. We have never practiced it, and any instance that can show any excuse for it simply shows the inadequateness of the previous time study that it is supposed to check.

69. The existence of a vestige of desire for secret time study of any kind simply shows a complete ignorance and disregard of the possibilities of hearty cooperation of the worker combined with micromotion time study that records *all* of the details. This was one of the subjects of our first meeting and conference with Dr. Taylor, and we have continued holding our same views ever since.

70. We regret exceedingly that Mr. Cooke does not take this occasion to declare himself on the subject of the desirability of accuracy of timing and recording in such permanent form that the workers can see for themselves and understand all of the motions and surrounding conditions of these errorless times from which tasks are set for mutual benefits.

71. We are greatly disappointed that he does not express himself on the desirability of having these records in such physical shape that they can be shown to the workers, that they may receive the benefits of "education thru the eye" which they so sorely need, of the new world of knowledge regarding their crafts and skill. It can hardly be said that Mr. Cooke has not had time to make up his mind, because he saw our micromotion data nine years ago.

72. We believe that the management engineering profession ought to hear what methods are used by Mr. Cooke in solving problems of skill in millions of possible combinations and permutations of therbligs or cycle subdivisions of the five-second cycles of the garment industry. Does he attempt to find the scheme of perfection of motion of this most highly repetitive industry by means of Mr. Barth's algebraic method recommended by Dr. Taylor in 1903 in spite of its complications, and based on erroneous original times, with no accurate data on the tools used and surrounding conditions existing? Or would he consent to recommend five feet of film for study, with every subdivision recorded automatically as to tools, surrounding conditions and times obtained by merely turning the handle of the camera?

73. He apparently stands for "less mystery." There is *no mystery whatever* regarding times and methods derived photographically.

74. Mr. Cooke's discussion would lend weight if he had expressed his views on Prof. Spaeth's statement that "the stop watch is already far too accurate," and it would have been particularly fortunate if he had stated that, other things being equal, the greater the accuracy of all fundamental data, the better. We wish he had stated his position regarding the statement of Mr. Barth, who says that he does not take Dr. Taylor's statement seriously, and whether he agrees with Mr. Barth or with us that Dr. Taylor was right when he stressed the importance of "unit times" as quoted in the opening paragraph of our paper. We also wish that he had expressed himself concerning the fact that there is practically no machine work in the garment industry that has not handling time that runs concurrently with the machine time, as emphatically as Mr. Barth and Mr. Merrick emphasized the absence of high percentages of handling times in certain branches of work in an arsenal.

75. Regarding Mr. Cooke's invention of a barking stop watch, we note with much interest that his stop watch neither barked nor wagged its tail at the principal topics of discussion of our Indictment.

76. We thank Mr. Cooke for his discussion of the reference to secret time study in our paper. May we assume that he accepts all of the other parts of our indictment of stop-watch time study, since he in no wise objects to it?

REPLY TO MR. MITCHELL

77. Mr. Mitchell has shown a greater appreciation of micromotion study than have any of the other discussors. He brings out in paragraph 1 its usefulness for comparing and testing methods, a use implied in our emphasis on the importance of deriving the One Best Way.

78. We are not sure what he means in the latter part of the paragraph. If he implies that the micromotion method may be used to evaluate stop-watch data, he is quite right. It has been so used, with startling results. He must surely realize, however, the wastefulness of such a process, since the "standard time," if desired, can be derived from the accurate record of the micromotion method, thus making absolutely unnecessary the "mass of varying readings" of the stop-watches.

79. He has brought out admirably, in paragraph 2, the vital defect of stop-watch time study. As he says, the methods vary, the data are not interchangeable. "They cannot all be best." We have confined ourselves in our paper to Mr. Merrick's method, as we consider Mr. Thompson's in detail in a forthcoming paper, and as we understand our friend Mr. Knoepple no longer emphasizes stop-watch time study.

80. Of course Mr. Mitchell cannot imply that micromotion study should be only a judge of the correctness of conflicting "times."

81. In paragraph 3 he speaks of "different readings for the same element," as being a "common experience." We should say rather, *universal* experience. He emphasizes well the variety and number of possible, no, practically unavoidable, errors. As he says in the first part of paragraph 4, these errors are "concealed" from the stop-watch observer. He does not overlook them, he cannot see them, while attempting to take accurate times with the "running watch." He states our views absolutely when he advocates taking records simultaneously with all the available devices, and comparing the data. The H. H. Williams time study machine is practically the same as one we invented and discarded in 1907.

82. We have micromotioned not only the observed man at work but also highly expert advocates of the stop-watch, timing the said worker simultaneously on many operations, and demonstrated that in the matter of times alone—a small part of the micromotion record, but all that compete the stop-watch records—the resulting records have invariably made all of the stop-watch data ridiculous and pathetic.

83. If any other stop-watch experts feel that they have anything further to offer, we ask nothing better than for some member of our organization to have a chance to complete with the master of each stop-watch method.

84. As Mr. Mitchell suggests, in paragraph 5, the micromotion method is ideal for recording "before and after,"—a real measure of both behavior and results.

85. We agree with him in paragraph 6, where he says "there are comparatively few classes of work elements." In fact, we believe that there are but sixteen sub-divisions of a cycle of motions. They are called therbligs. They are as follows:[1]

1. Search, 2. Find, 3. Select, 4. Grasp, 5. Transport loaded, 6. Position, 7. Assemble, 8. Use, 9. Disassemble, 10. Inspect, 11. Pre-position for next operation, 12. Release load, 13. Transport, empty, 14. Rest for overcoming fatigue, 15. Other forms of unavoidable delay, 16. Avoidable delay.

86. Mr. Mitchell seems to be remotely groping for these in his "pick up," "put down," "drop," etc. He is quite right in saying that "these cannot be timed directly by the running decimal watch." Also he is right beyond the slightest doubt in believing that the study of them will lead to really scientific job analysis, instruction cards, times and standards.

87. We had the honor of explaining this to Prof. Mitchell at our house more than four years ago, and we regret that he still emphasizes the value of the feature of errorless timing more than the possibilities of recording the method with such perfection that it can be used for any purpose of re-examination that may come up later, including, of course, synthesizing the One Best Way to do Work.

REPLY TO PROFESSOR SPAETH

88. Professor Spaeth's discussion stands in a very different class from the others. He has none of the advantages or the disadvantages of knowledge of the history and theory of Scientific Management. He has no experience in the practice of Scientific Management. His discussion is, therefore, of importance not as an opinion as to the values of the stop-watch method and the micromotion method, but as reflecting the "state of information" or lack of information today of the highly trained physiologist and psychologist, as to

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[1] These therbligs were first disclosed in the pioneer paper in any language on reeducation of the crippled soldier. See "Motion Study for the Crippled Soldier." Journal American Society of Mechanical Engineers, 1915.

the problems of modern management and their solution.

89. It must be remembered that Professor Spaeth is an expert in physiological hygiene, but not in time study, motion study, or skill study, therefore, in accordance with the time honored practice for courts of law, his opinion is to be accepted as *testimony* and not as *evidence*, and, as in all cases where one is not an expert in the subject under discussion, he must prove each statement that he makes in order to give it weight.[1] His testimony will not have weight merely because he is a recognized expert in other professions, or even because he has rendered valuable service to industry by contributions to Fatigue Study, thru the Committee of the Society of Industrial Engineers, and otherwise.

90. We must, therefore, consider Professor Spaeth's discussion on its merits as determined by measurement.

91. In paragraph 2 Professor Spaeth states that he believes that we have "lost sight of the fact that the problem of time study is not one involving extraordinary accuracy in measuring time." To which we reply that "time study" is but a small portion of the subject of our paper. Until it is realized that time study is one thing and motion study another and entirely different, it will not be appreciated that what we are discussing is a much greater problem than mere time recording. We have stated repeatedly and emphatically that *deriving the One Best Way is the chief aim of our methods*. We have stated that this One Best Way known is offered as an ideal of achievement to the learner, and used as a base line from which the improvements suggested by the workers may be measured and rewarded. We are obliged to assume that Professor Spaeth is completely unaware of the existence and uses of our Simultaneous Motion Cycle Charts,[2] which are made from data on the film, or he would not think for a moment that we place much emphasis on time records as compared with motion records.

92. Nevertheless, in such problems as that of determining in advance which of many will be eventually the One Best Way To Do Work, we must have accurate times, otherwise it is impossible to distinguish between *merit of method and, state of dexterity and automaticity* of the observed demonstrator of the proposed method, or method under consideration.

93. To illustrate, let us consider a proposed method for doing a piece of work at which the demonstrator has little or almost no practice, as compared with an existing method at which he has had much practice. The former may and often does take three to ten times as long to perform as the latter, when the proposed method is first demonstrated. A proposed method must be analyzed by the micromotion process into its therbligs.

94. In no other way can the ultimate achievable times of a new method be accurately prophesied, and the method undertaken and carried with confidence thru the learning period, until skill is achieved.

95. For definite and simple examples of this one should try writing one's name; 1—upside down; 2—backwards; 3—mirrorwise; 4—various combinations of 1—2—3. To do this simple experiment will require approximately from three to ten times the length of time which one requires to write it in the customary manner, yet the only change is the effect upon one's automaticity, due merely to the simple change of the variable, *direction of motions*.[3] A study of the times of the worker under the same condition of automaticity at work at which he is skilled, will give information as to his ability at similar and at dissimilar work. Therbligs must be synthesized from their fatigue standpoint, not their time standpoint unless under similar conditions of automaticity for all methods being tried. Therefore the stop-watch is out of the question on such work.

96. Our standards of times for individual and combinations of therbligs can then be used to furnish the times. If this were not possible we could not select the method that would eventually be the One Best Way until automaticity had been actually achieved in all methods considered. Obviously, a

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[1] "The normal function of a witness is merely to state facts within his personal knowledge. An expert witness who can prove his qualification as such by special training and experience in a particular line is permitted to state an opinion or inference drawn by him based on an assumption of the truth of facts proven by other evidence.

"In all cases in which opinion evidence is admitted in a court of law it is essential that the witness should be possessed of adequate special experience and knowledge of the (precise) subject matter to which his testimony relates,

"Chateaugay Etc. v. Blake 144 U. S. 476.
American Car etc. Co. v. Thornton 183 Fed 114.
Parsons v. Syracuse etc. R. R. 133 N. Y. App. Div. 461.
Burroughs v. N. J. Gas Co. 88 N. J. L. 634,

and that the witness is specially qualified to draw a correct inference.

Feuchtwanger v. Manitoc Co. 187 Fed. 713.
Samuels v. U. S. 232 Fed. 536."

[2] See "Applied Motion Study" Pages 138-9. "Motion Study for the Handicapped" Pages 30-31.

[3] For list of variables of motions see "Motion Study," Pages 6 and 7.

hopeless task! It is the failure to recognize this point which makes re-examination of methods derived by stop-watch time study such a fertile field for possible savings. We have now hundreds of thousands of timed therbligs transferable to any kind of work where human motions and decisions are made. The achievement of books of errorless time study, transferable and interchangeable on all kinds of work, is now assured.

97. Professor Spaeth, as a psychologist, ought also to appreciate that *speed is an important variable in automaticity,* and that when a worker operates at more than a certain amount below the speed of his automaticity, his manual process is transferred from his unconscious mind to the conscious mind. Therefore, the greater the accuracy of the records of the times, and the relative times of the therbligs, the greater the value of the original data, from the *Skill Study Standpoint.*

98. It is a law of motion study that fast motion and slow motions do not and cannot occupy the same paths in space. This fact we have used as a working theory since 1885, but it was not until we had perfected the apparatus of micromotion study and the stereochronocyclegraph methods that we were able to record the amount of variation from paths of the economic speeds, the amount and effect of muscle rebound, the conscious interference of automaticity, and the phenomena of behavior in general. These data proved by exact records of practice the correctness of our general theory and practice, that one of the greatest hindrances to progress in learning the trades is the usual and customary practice of teaching the learner to begin his learning at *demonstration speed,* and then, after having acquired the ability to produce an acceptable quality together with the automaticity of such demonstration motion, expecting him to learn a different set of combinations of motions of different paths, with a resulting habit interference for the rest of his life. For example, to the observer's eye, it may appear that both hands and eyes arrive at certain locations simultaneously, and he will so record. Then, perhaps, his ear will note the sound of the motions or the use of tools, which show that the motions were not precisely simultaneous. The errorless micromotion process records the facts, and shows that if motions are ever performed exactly simultaneously it is so rarely as to be negligible. In other words, there is no such thing in motion study as simultaneity of performance of two anatomical members of the body. For practical work, variations of less than 1/4000 of a minute are considered as simultaneous. However, records can be made with any degree of accuracy desirable without extra effort and the results can be regrouped as desired.

99. The "five per cent error" that Professor Spaeth expects is enough to make data on this subject useless for finding laws for methods of least waste in learning processes for acquiring the super skill of the One Best Way. All such errors are, of course, eliminated by the micromotion process.

100. The lateness of the hands which follow in or near the paths made up of the sequence of locations of points of focus thru which the eyes have already passed is an indication of the degree of automaticity, skill, distraction and habit interference at the particular method recorded. Conversely, the lateness of the eyes, if they follow the sequence of locations of the hands, is evidence of subnormality. The quantity of time late is too small to measure with a stop-watch, and of course the relative locations of the eyes and hands cannot be determined or recorded by the stop-watch method.

101. The greater the amount of automaticity, the greater the amount of space, the greater the amount of time and the greater the number of therbligs that the hands are late, or behind time, in following the eyes, in each cycle of the operation. In fact, it might be said regarding the motions of the hands and eyes, that the amount of variation from simultaneity is an index of one's automaticity. Regarding the motions of the two hands, the percentage of therbligs begun simultaneously is an index of skill. The greater the percentage of therbligs begun simultaneously with both hands, the greater the skill.

102. We had the honor of co-operating on a problem of lateness of the lips, as compared with eyes, in reading tests made on young children of various ages. This last subject, however, can be explained best by Professor Courtis, an engineer in education, author of the Courtis Tests of Educational Methods, who believes that correct fundamental records of actual performance are the basis of all progress in education. Professor Courtis is to be congratulated on the pioneer work which he did long before his remarkable theories and practice were appreciated. Many similar problems can be cited; for example; the effects of variables on constructive imagination; the likeness of the motions of epileptics in seizures to automaticity of the skilled worker, etc.

103. These are a few typical studies that require accuracy of paths of motion in three dimensions and accuracy of timing.

104. It must always be remembered that our records of *the best man obtainable* become the norms for all such scientific investigation. Such records, taken primarily for scientific purposes, have invariably helped us to find and use the laws of motion study, absolutely necessary for teaching the One Best Way to do work to organizations on a large scale.

105. All of these facts are shown beyond argument or doubt in the Simultaneous Motion Cycle Charts. When the result is unsatisfactory the place and the cause can be located on the chart and corrected. Therefore, the determination of fundamental laws for synthesizing methods of least waste for the skilled, as well as the learning process of all manual education, demands data regarding Skill Study, which at the present time is a subject unrecognized in any college curriculum, and is not given the slightest consideration by Professor Spaeth at the time that he criticises the micromotion method. This subject must be recognized, and will be, to compensate for the trend of modern industry in specialization and standardization of the workman, and in the division of labor. This is absolutely necessary, that the underlying principles regarding the skill of super-specialized workers may be most efficiently transferred, and that the underlying principles of methods of least waste and greatest productivity may be taught a worker regardless of how small a subdivision of the whole his particular division or specialty represents.

106. In paragraph 3 we are astounded to find that Professor Spaeth says, "In my opinion the stop-watch, instead of being inaccurate, is already far too accurate." Compare this with what Mr. Barth says in his paragraph 5: "Of course, it would be preposterous to maintain that, even with a somewhat uncertain final quantity to be measured, it would not always be desirable to employ the most refined measuring device obtainable." Professor Spaeth's paper deals only with time study, not motion study. Therefore, he has missed everything that has to do with complete recording of all behavior of the super-expert to find the scheme of perfection of method of work, or perfection of method of teaching perfected method of work. If he recognized the possibilities based upon actual accomplishments of the micromotion method together with the fact that errorless times are a free by-product, it would seem possible that perhaps he could learn to use our errorless times as a base, afterward changing each of them to such degree of inaccuracy as he desires.

107. Professor Spaeth points out, in paragraph 3, what he considers the errors of stop-watch time study, and implies that the micromotion method shares in these. In our paper we endeavored to confine our principal criticism to the statistical standpoint leaving other criticism for later papers, as we there stated. That our statistical arguments do apply to micromotion study data is proved by the practice which enables us to determine from accurate data whether or not the observed worker is of the highest order, for purposes of demonstration and for permanent data. We shall not endeavor to defend the stop-watch method from his attack, but shall here discuss simply the application of his remarks to our method. It must be said, however, at the start, that by his last sentence in this paragraph Professor Spaeth shows that he does not appreciate Dr. Taylor's great invention of timing the work period and the rest period separately. This seemingly unimportant invention of Dr. Taylor's is seldom appreciated, but those who really understand the Taylor System as well as the Taylor methods are in complete agreement with Dr. Taylor's belief that this separation of the timing of work from the timing of rest is imperative for best results.

108. Delays are of two kinds, avoidable and unavoidable. They must be accurately recorded and classified. Unless they are accurately recorded and classified, it is impossible to plan for the utilization of both the periods of "avoidable delay," (therblig 15), and "unavoidable delay" (therblig 16), for the purpose of "rest for overcoming fatigue," (therblig 14). As a result the amount of fatigue allowance that can run concurrently cannot be deducted from the total amount of allowance of rest for overcoming fatigue, and consequently the correct amount of time to add to the net time of an operation cannot be determined.

109. The amount of fatigue allowance is best estimated as a percentage of the synthesized time of the work cycle. The more inaccurate the time of the work cycle, the more this inaccuracy is compounded. Nothing could be more ridiculous, statistically, than "fatigue curves" based upon inaccurately observed stop-watch time study, averaged to the fourth decimal and with no data whatever regarding the fatigue causing factors,—no statement whether the observed worker had chair, nail keg or tote box to sit on, etc. This one point alone, handled and covered to perfection by the micromotion method, should be considered

when reading Professor Spaeth's remarks on uncertainty of fatigue data.

110. The question of incentives, as introduced by Professor Spaeth, involves supplementing a study of how much a man *can* do, by a study of how much he *will* do, but the former is an essential element in the latter. Four steps are involved:

a. Find the One Best Way to do Work;

b. Identify the method so that there will be no misunderstandings as to what is to be taught or what is to be learned;

c. Determine how long it takes to do the work in accordance with the clearly defined and identified method;

d. Consider the incentives that will induce the worker to do as much as he can, and thrive, and improve in his health simultaneously.

These four steps make a dependent sequence not to be tampered with by anyone.

111. The "variability of individuals" and the suitability of jobs and men we shall consider a little later, where Professor Spaeth again refers to them. It is well to mention here that because of the fact that we observe only the super-expert or super-experts, we do not need to be reminded that it is "not exceptional experts with whom we are forced to work in practice." We observe the best there is that we may learn and that their priceless information may be put at the disposal and the use of workers of the present and the future generations. It goes without saying that the "given man[1]" will be the best obtainable of a kind that will be permanently satisfied with the job itself, or with the job as a stepping stone toward a more desirable one. He will vary as to quality according to a great many factors outside the scope of this paper. Of course he will not be expected to do as much work, or as good quality, as the best man obtainable, and a due allowance must be made accordingly.

112. We may say here, however, that while it is desirable to have each grade of work done by workers as nearly alike as possible, this is not practicable, and it is not essential, because those who are still superior to the others will earn more money, which they should. It is neither necessary nor desirable to herd workers into classes, but each should be helped and lifted as far as possible, and each should be paid for his results. If the method of least waste is taught and becomes the method at which one has automaticity, the resulting inequalities in possible performance of two workers who vary greatly in the other respects which Professor Spaeth emphasizes, simply affect the quantities of their pay. The *method* is determined by the recording of the behavior and motions of the super-experts and the task by the capabilities of the least efficient workers who are to work at that work permanently.

113. There is nothing new about this practice but it completely answers and eliminates all of Professor Spaeth's objections in his parable of the chemist. Surely no thinking man would prevent a worker from learning all possible regarding the most accurately acquired data from the super-expert, simply because workmen differ as to the amount of fatigue they acquire,—or the difference in their strenuosity, brawn and brain, or the difference in effectiveness of the same incentive. These are handled as problems of obtaining utmost skill and greatest productivity according to ability, natural aptitudes, and attainments, and utmost money according to fitness and perseverence. Because these differ greatly is no reason for confusing with them the problem of the accuracy of the One Best Way to do work.

114. Regarding the problem of incentives for workers for maximum economic effort we would call Professor Spaeth's attention to the fact that the worker's pay is a matter of definite percentages above the wages to be obtained elsewhere, on similar kind of work where the workers can take it easy. Of the amount of this percentage which ranges from thirty to one hundred per cent, Dr. Taylor says[2]: "The exact percentage by which the wages must be increased in order to make them work to their maximum is not a subject to be theorized over, settled by boards of directors sitting in solemn conclave, nor voted upon by trade unions."

115. After basic wages for work have been determined by general or local industries, the motion and time study men determine the relation of the method and quantity of output to the time and additional compensation.

116. As for the remainder of paragraph 4, in criticising "the final result" he forgets that what we are stressing is the accuracy of the micromotion method, and the accuracy of the results as obtained by the method. We did not explain this method and the cyclegraph method in our paper, both because we have explained them elsewhere, and because the paper confined itself, as far as possible, to an indictment of the stop-watch. We submitted our methods simply

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[1] See "Psychology of Management," Page 152.

[2] See "Shop Management," Paragraph 32, Harper Edition, Page 25.

to show that an alternative was available that could do the work better.

117. With our method we can record skill, and we can measure degree and causes of skill. We can determine the One Best Way, and determine and measure the variation from the One Best Way. We can determine commonest pitfalls of method that handicap a worker for life. We can transfer skill from one subject to another. We do not combine unlabeled facts with unlabeled guesses into a "final result," and then claim that we have a scientific achievement. Professor Spaeth knows that any chemist of repute would scorn to make a combination such as he suggests and pretend to call his mixture accurately determined. Why should he imagine that any engineer of long experience would be less particular?

118. In paragraph 5 Professor Spaeth hints that our work is of little value in practice, where it is necessary to deal with "average" men. Perhaps the best answer to this is that we have applied it successfully for years to all kinds of men in all kinds of work. As for the benefits to the same "average workman" from studying the film, the fact that Professor Spaeth is "skeptical," only shows that he has made no intensive study of the possibilities of visual education, in general, and the actual effects of our micromotion study on the training of the worker, in particular. We must say frankly that we have no trouble convincing the workers, compared with that of convincing those who theorize about him. Besides, there is no reason to limit the worker merely to five feet of film and a magnifying glass. Five feet of a film of a super-expert, together with a magnifying glass will open the door of knowledge to anyone. The possible results are not to be doubted; they are actual. The material is at his disposal.

119. Professor Spaeth apparently is not aware of the advantages that come to the worker himself and to his associates and employer, as a result of teaching him to *think in terms of elements of motions.*

120. In paragraph 6, Professor Spaeth concedes the value of our work "as a research method and as a permanent record of the best way to do work." This is all we need. If he acknowlerges that, all that we claim for it follows, as we shall show. As for attempting "to control some of the larger errors" before increasing our refinements in one direction, it is thru these very refinements that we get the knowledge and facts to control that he advocates. This is the heart of the whole argument. The attending fatigue causing or eliminating conditions, already referred to, furnish a typical instance of the case in point. The effect on the workers from their control of analysis and synthesis not only makes all work less monotonous and more interesting, but is also educational. Education of the workers has too often and too generally been neglected. Actual practice shows that the micromotion method has done more to cause the workers to think logically and to utilize to advantage their entire fund of craft knowledge than any other one thing.

121. In paragraph 7, the importance of standardization of the *material* element is outlined,—a matter upon which we all agree. The importance of standardizing the *human* element is demanding universal attention also. By such standardization Mr. Spaeth certainly has no thought of limiting the worker's opportunity, but of studying the worker as well as his work to discover "fitness" and insure better placement.

122. The three phases of such standardization are listed in paragraph 8. The account of Dr. Martin's work in paragraph 9 is very interesting and well serves to illustrate much similar work being done in this line abroad, as well as in many parts of this country, including our own laboratory. So do the physiological tests referred to in paragraphs 10 and 11, and the psychological tests referred to in paragraphs 12 and 13. All management men are not unacquainted with such tests, as Professor Spaeth seems to think. Our testing of such psychological tests as those for the selection of candidates for training in world championship contests of typewriting, were carried out in great detail five years ago, and others as far back as 1912. The elaborate paraphernalia of such minute investigations as those being made in their laboratories by Professor Schlesinger, Professor Moede and Doctor Piorkowski,—all of which we have had the honor of inspecting at their invitations,—and their results and applications to and implications in industry, have been carefully investigated by several industrial engineers, at least, who have travelled abroad for years, as well as thru the laboratories of this country, seeking closer affiliation with investigations in the field of physiology, psychology and psychiatry.

123. In paragraph 14 is discussed the illusive character of fatigue and the power of suggestion. It is scarcely necessary to mention that such experiments would not and could not be tolerated in the industries. We agree with Professor Spaeth that the will must be studied and the importance of motivation appreciated. both in its effects on the conscious and the uncon-

scious mind. We realize the importance of investigating inhibitions, and of "releasing" co-operation. We also second most heartily his suggestion that all who study the human element co-operate, as voiced in his final paragraph. This, however, can by no possible stretch of the imagination be called an "untouched field."

124. Professor Spaeth has been exposed to the doctrine of Behaviorism so long that it is astounding that he does not recognize that both changes in manual processes and in mental processes and attitudes manifest themselves in behavior, in action. Mental processes and the resulting behavior can now be photographed. For such purposes we have used for seven years with most satisfactory success sterescopic motion pictures examined and charted at leisure, descriptions of which will be given in one of our forthcoming books. Photographing of mental processes as indicated by behavior is the special work of the micromotion and the cyclegraph methods. They were specially devised for this work, they have been developed and supplemented so that now we can obtain records that completely satisfy not only our needs in the industries, but such psychiatrists as the late Dr. E. E. Southard, with whom we co-operated for many years, and such expert psychologists and educators as Professor S. S. Colvin, whose "Learning Process" serves as a guide book in the industries as well as the schools and colleges. The epileptic specialists, such as Drs. L. D. Damon, G. Kirby Collier, W. T. Shanahan, and Dr. Arthur L. Shaw have used our records in studying the epilepsies and the National Safety Council under the leadership of Mr. Louis Resnick and Mr. S. J. Williams have used our conclusions to reduce the "irreducible minimum" in accident prevention.

125. Human standardization, if that means understanding the human element and classifying work and men so that the human element can develop, *is* the great work of today and tomorrow. But it can only take place when accuracy of devices and records is insisted upon *absolutely*, with no exceptions.

126. Human standardization is desirable only when it raises the standard; when it raises each human being to the standards above. To raise them we must first find the One Best Way and then survey their differences as to method and education. The other differences will, of course, be reflected in the payroll, as they should, and will permit the most efficient to earn the most wages. There can be no logical objection to that.

127. It may not be advisable for mechanical engineers or industrial engineers to carry this psychological discussion further. We therefore will leave Professor Spaeth in the hands of his brother psychologists one of whom, Dr. Henry C. Link, has recently written a most inspiring paper on "The Application of Psychology to Industry."[1] We quote from the opening paragraph:

128. "Psychology as applied to industry is today on the defensive, partly because industry has expected quick, concrete returns, whereas psychology could offer only piecemeal, tentative conclusions; partly because psychologists have approached industrial problems with an assurance which they were unable to realize in actual practice. On the part of business men there has been a failure to appreciate the necessary refinements of the psychological methods. On the part of the psychologists there has been a failure to understand the intricacies of industries."

129. There may still be some question whether the most desirable training consists of *preparation in engineering supplemented by training in applicd psychology* or *training in psychology and education supplemented by training in engineering and practical work in industry*. Certainly we agree absolutely with Dr. Link that training in both lines is necessary. In the meantime, industry is justified in questioning the advice of those who neither understand her theory, her needs, nor her practice.

SUMMARY

130. To summarize;—the managers and stop-watch time study experts who have discussed our paper have in no wise strengthened the arguments in favor of stop-watch time study as embodied in Mr. Merrick's book, neither have they brought any criticism against the micromotion method except its alleged greater cost.

131. Professor Spaeth also has in no wise justified stop-watch time study, even from the stop-watch man's standpoint, for while they all contend that it is accurate enough, he says it is too accurate. We are glad that no engineer ever made this statement, but we regret exceedingly that every member of the Philadelphia Section of the Taylor Society let his statement go unchallenged and without dispute.

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[1] Phychological Bulletin, Volume 19, No. 10, October 10, 1920.

132. We would ask here, why have these gentlemen confined their discussions to two minor points? Why has no one disputed the principal points of our paper, such as the following:—

a. That stop-watch time study is unethical in so far as it does not define clearly, and in as much detail as possible, the subject matter of the contract between the employer and the employee on which the money paid for achievement and productivity is based;

b. That stop-watch observations lack permanent value;

c. That the stop-watch does not record surrounding conditions;

d. That stop-watch time study is useless from the standpoint of Skill Study;

e. That stop-watch time study does not record anything regarding the priceless methods of the super-skilled expert, or best demonstrator obtainable;

f. That the accepted methods of the stop-watch enthusiasts for handling stop-watch data are wrong from the statistical standpoint;

g. That there is no attempt under the stop-watch method to instruct the worker regarding the details of those methods which excel his;

h. That there is no standardized procedure for synthesizing better methods under the stop-watch method;

i. That to find the One Best Way to do work under the stop-watch method is impossible;

j. That there is no realization of similarity of the practice of the stop-watch method to the "rule of thumb" practice of the old fashioned manager;

k. That with the stop-watch method there cannot be obtained any records of the "single small elements" that Dr. Taylor demanded;

l. That the laws of habit formation and automaticity, that underlie an efficient learning process and least waste in future practice, are not discovered or utilized?

133. These and many other claims regarding the deficiencies of stop-watch time study and the superiority of micromotion study have not only remained undisputed, but undiscussed. Why?

134. Perhaps we should have described the micromotion method more fully in our original paper, in order to demonstrate not only that the stop-watch method is inaccurate, but also that its use is absolutely inexcusable, because the micromotion method can do the work of the stop watch better than the stop watch can, and can also supply all the lacks in the stop-watch method. There is not space enough to discuss our methods at length here. They have been fully described.[1] The methods and the films themselves have been offered for observation and for use to our fellow managers, to the engineering profession, to education, in fact to all to whom they can be useful.

135. We have mentioned but a small fraction of the uses for complete and correct data. Such data will in the next few years more completely revolutionize methods of industrial teaching and of production than did knowledge of machine design change machinery.

136. If we have seemed to repeat ourselves unnecessarily in mentioning certain features of the micromotion method in this closure, it was because it was necessary to answer the discussors paragraph by paragraph and point by point.

137. It is not our function to judge finally between the merits of the methods, having presented ours and pointed out the differences. Neither is it our place to pronounce judgment upon the calibre of the opposition that we have received. We commend Professor Spaeth and his attitude toward accuracy to his brother psychologists. We recommend the Philadelphia Section of the Taylor Society itself for decision as to whether the Society backs up or repudiates the representatives of the Section who confirm or assume the superiority of, or justification for, the inaccurate non-method-recording stop-watch time study, and who remained seated and permitted such statements as were made at this meeting of the Philadelphia Section of the Taylor Society to go unchallenged.

138. Finally, in accordance with the decision that the Taylor Society makes on this matter, we commend the Taylor Society to the Engineering Profession, as having lived up to, or failed to live up to the second article of its own "Management Engineers Creed," which states: "The sublimest duty of the engineer is to keep the faith"—to—"remain true to his science."

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[1] "Applied Motion Study," "One Best Way," "Fatigue Study," "Motion Study for Handicapped."